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Characterization of maize inbreds in testcrosses for plant and ear characters and yield at varying plant densities and effectiveness of selection in successive generations of inbred progenies for improvement of hybrid yields

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I. INTRODUCTION

An accurate evaluation of inbred lines in any maize breeding program must be accomplished if the program is to be successful. Because of the shift of interest in recent years from double crosses to single crosses, the maize breeder must develop inbred lines that have high yields *per se* as well as contribute high yields to the single-cross combinations. Consequently, the evaluation procedures will emphasize additive gene action in the selection and evaluation of the inbred lines, but nonadditive gene action is likely to be of considerable importance in the single-cross hybrids. Perhaps a knowledge of relationship of inbred characters with single-cross performance is even more important than when double crosses were used.

For several years maize yield increases in the Corn Belt have been achieved by increased plant densities and higher fertility levels. Not infrequently, some hybrids that were superior at lower plant densities and moderate fertility levels did not give positive yield responses to cultural changes. Such hybrids often were observed to have a high degree of barren stalks at the increased stand densities. Effects to plant and ear characters by these high productivity practices and the relationship of these effects to yield responses have not been thoroughly studied. Also, in earlier years several maize breeders studied the relationship of the inbred plant and ear characters with hybrid performance. Similar studies in the high stand densities and high fertility levels have not been made. Whereas in earlier years hybrid performance of the inbred lines could not be accurately predicted on the basis of the inbred line characteristics, perhaps this situation has changed in the maize culture used in the Corn Belt today.

Russell and Teich (1967) reported on comparisons for hybrid performance of inbred selections developed in a study of breeding procedures. These lines, developed by selection among and within progenies from M14xC103, were evaluated for inbred and hybrid performance at two and three plant stand densities, respectively. Their results suggested that more detailed studies of some of the inbred lines were warranted, thus the basis for this thesis study.

The purposes of this research were as follows:

1) For a selected group of the M14xC103 inbred lines, to study in testcrosses the relationships of important plant and ear characters to grain yield and to determine the effects of varying plant stand densities on these relationships.
2) For the lines in 1), to determine the rate of cob growth at the two top ear nodes during the period of rapid ear shoot development before silk emergence and to relate this cob development to the hybrid performance of the lines.
3) For a selected group of the M14xC103 inbred lines, to determine if the high or low testcross yield performance of the generation evaluated by Russell and Teich (1967) was caused by the yield level of the F_2 genotype or by genetic segregation and selection in the F_3 and F_4 generations.

II. REVIEW OF LITERATURE

The effect of plant population densities on yield, yield components, and some plant characters of corn genotypes at the hybrid level has been a subject of evaluation for a long time.

Long (1961) reviewed results from more than 175 separate experiments with corn in which N and/or spacing variables were studied. These experiments covered a period of over 50 years, 1907-1960. He stated that in most instances a stand not exceeding 12,000-15,000 plants per acre appeared to be adequate for the full season, prolific hybrids used in these experiments. Higher plant population gave no improvement in yield and increased the lodging problem. However, Colville et al. (1964) reported that the recommended rates of planting, suggested by seven other authors, ranged from 12,000-24,000 plants per acre in humid areas to 6,000-12,000 plants per acre in nonirrigated, semi-arid regions.

Although these studies show a trend of yield response to plant population levels, one must keep in mind that these experiments have been carried out in different environmental stresses and even with different population levels, and the most important is the different genetic constitutions (genotypes) that have been used.

An extensive investigation of the effect of increases of plant densities on several plant and ear characters as well as yield were reported in the early 50's and late 60's.

Plant height was reported to be increased as density of planting increased by Wolf and Howard (1957), Norden (1961), Colville and McGill (1962) and Ortiz-Cereceres (1967); however, no effect was reported by El-Lakany (1965) and Rutger and Crowder (1967).

The general trend that ear height increased as plant density increased was found by Zuber and Grogan (1956), Zuber, Grogan, and Singleton (1960), Colville and McGill (1962), and Rutger and Crowder (1967).

Number of ears per plant was reported to decrease as plant density increased by Zuber and Grogan (1956), Wofford, Horner and McCloud (1956), Hemingway (1957), Wolf and Howard (1957), Omar (1958), Dungan, Lang and Pendleton (1958), Bayer and Dorywalski (1960), Zuber, Grogan and Singleton (1960), Norden (1961), Ramirez and Laird (1961), El-Rouby, El-Khishen and Aboul-Ela (1961), Warren (1963) and El-Lakany (1965). On the other hand, Bryan, Eckhardt and Sprague (1940) indicated no effect for plant density on number of ears per plant, and Saunders (1942) reported an increase of number of ears per plant with increased plant densities.

Ear length decreased as plant density increased as reported by Hemingway (1957), Wolf and Howard (1957), Bayer and Dorywalski (1960) and Ortiz-Cereceres (1967).

Ear diameter was not affected by population densities as reported by Wolf and Howard (1957), but Ortiz-Cereceres (1967) found it decreased as the plant densities increased.

Ear weight was reported to be decreased as plant population levels increased by Hinkle (1950), Wolf and Howard (1957), Omar (1958), Bayer and Dorywalski (1960), El-Rouby, El-Khishen and Aboul-Ela (1961) and El-Lakany (1965). Watson and Davis (1938), Thomas (1956), El-Hattab (1957), and Pumphrey and Dreir (1959) indicated that ear weight was affected by population levels. However, Saunders (1942) reported an increase in ear weight as plant population levels increased.

Ear size was reported to decrease in a somewhat linear trend with increases in plant density by Zuber and Grogan (1956), Duncan (1958), Zuber, Grogan, and Singleton (1960), Baracco (1961), Pendleton and Seif (1961), Schwanke (1963) and Warren (1963).

Kernel depth generally decreased with the increase of plant density as reported by Ortiz-Cereceres (1967).

Shelling percentage was not much affected by densities of planting as reported by Bryan, Eckhardt and Sprague (1940), Omar (1958), Stickler and Lande (1960), El-Rouby, El-Khishen and Aboul-Ela (1961), and El-Lakany (1965). On the other hand, Hemingway (1957) and Ortiz-Cereceres (1967) reported that shelling percentage decreased as plant population levels increased and the latter reported a highly significant difference ($p = 0.01$) for shelling percentage when the stand level changed from 16,000 to 24,000 plants per acre.

Seed size was reported to be decreased and differed significantly when plant populations changed from 16,000 to 24,000 plants per acre by Ortiz-Cereceres (1967). Bayer and Dorywalski (1960) reported a decrease in the weight of 1,000 seeds as plant density increased.

Number of seeds per plant was reported to be decreased as plant density levels increased by Hemingway (1957). Bayer and Dorywalski (1960) indicated that number of seeds per ear decreased as plant population levels increased.

Silking and pollen shedding dates and the interval between silk and shed dates were also studied to determine the effect of plant density increases on these characters. Wofford, Horner and McCloud (1956) reported that plant density increases did not affect silking date; however, Baracco (1961), Woolley, Baracco and Russell (1962), and Rossman and Cook (1966) found a delay of as much as one to five days in silking dates resulted from plant density increases. Kahnke and Miles (1951) reported a delay in silking of one day for each 3,500 to 4,000 plants per acre increase. Shubeck and Caldwell (1955) reported that an increase in plant density from 3,556 to 17,780 plants per acre resulted in five days delay in silk emergence. Woolley, Baracco and Russell (1962) noted an increase in the anthesis silking interval of 1.2 days with increases from 16,000 to 24,000 plants per acre during a favorable year, and 4.4 days in an unfavorable year.

Maize breeders have studied relationships between the yield of inbred lines and plant and ear characters on the one hand, and the correlation of such information and the behavior of these inbreds in hybrid combinations.

Hayes (1926) presented the results of some studies of the characters in inbred lines of corn which, in general, are correlated with vigor. Yield of selfed strains was strongly correlated with characters such as ear length, number of ears and, to a less degree on the average, with size of seed. He also reported that in some varieties seedling vigor was more strongly correlated with yield than in other cases.

Nilsson-Leissner (1927) reported the results of a study including 22 selfed lines and 100 F_1 single crosses between them. The lines had been selfed from 4 to 7 generations. Correlations between the average expressions of yield, ear length, ear diameter, number of kernel rows, percent of second ears, and plant height in the parental lines with the same characters of the F_1 cross progenies were highly significant and positive, ranging from 0.74 to 0.94. Multiple correlations of yield of F_1 crosses in relation to the average of each two parental lines for the six characters previously mentioned was 0.66 for the dent inbreds and their F_1 crosses and 0.82 in the flint inbreds and their F_1 crosses. He concluded that the results demonstrate that selection among the selfed lines for the characters desired is of value and that crosses between the more vigorous selfed lines yield better on the average than crosses between less vigorous inbreds. However, the author emphasized that the only method of learning the better F_1 combinations is by actual trial.

Jenkins (1929) studied the relationship between yield and yield components and some other agronomic characters of corn inbred lines and their F_1 crosses. He reported that within the inbred lines he obtained positive, significant phenotypic correlation coefficients between yield and plant height, number of ears per plant, ear length, ear diameter, and shelling percentage. On the other hand, he obtained negative, significant correlations between yield and date of silking, shrinkage of harvested ears, chlorophyll grade and ear-shape index. Yield of the F_1 crosses was correlated significantly and positively with the following characters of the parental inbred lines: date of tasseling, date of silking, plant height, number of nodes per plant, number of nodes below the ear, number of ears per plant, ear length, ear diameter and yield. On the other hand, there was a negative, significant correlation between yield of the F_1 hybrids and ear shape in parental inbred lines. He concluded that the most productive crosses may be expected from the most productive inbred parents.

Johnson and Hayes (1936) found in a study involving 39 sweet corn inbred lines and their topcrosses to the parental variety that the yield of the crosses was associated in only a small degree with the characters studied in the lines. A few significant, but low, correlations between yield of the topcrosses and the characters of the inbred lines were obtained. Ear length and stalk diameter of the inbred lines tended to be positively correlated with topcross yields, and number of suckers per plant negatively correlated with combining ability as judged by yield of the topcrosses.

Aylesworth (1948) found highly significant correlations between some inbred characters and the same characters in the inbred-variety crosses. Correlations between yield of the inbred-variety crosses and characters of the inbred lines were positive and significant in the case of date of silking, plant height, yield, ear length, and date of pollen shedding. The multiple correlation of 0.594 for the relationship between inbred-variety yields and eleven inbred characters was not significant.

Ortiz-Cereceres (1967) compared the performances of 124 S_2 inbred lines derived from a Corn Borer Synthetic No. 3 and their testcrosses to the parental variety planted at two different population levels, 16,000 and 24,000 plants per acre, at each of the three locations. He also studied the influence of plant population levels on the correlation among the seven agronomic characters plant height, ear length, ear diameter, kernel depth, grain yield, shelling percentage, and 300-kernel weight, as expressed in the two types of progeny. The phenotypic correlation coefficient calculated for each character as expressed in different progeny types at the same population level and in the same progeny type at different population levels indicates that selection for any character in the inbred lines at both population levels may be as effective as selection for the same character in the testcrosses at both population levels. Since a high correlation among all characters of the inbred lines at low and high population levels was found and since it is easier to handle the inbred lines at a low population, the evaluation of all characters in the inbred lines at a low population is suggested. The correlation coefficient obtained between each character and grain yield calculated within each progeny-type, population-level combination indicated that selection for any of the characters ear length, ear diameter, kernel depth, or shelling percentage would result in selection for yield in the same direction. Selection for any of the characters kernel depth, grain yield, or shelling percentage in the inbred lines grown at low population may result in selection of inbred lines with high general combining ability.

In recent years the effects of plant population level during the development of the inbred lines to be used in hybrid combination have been explored. Ferguson (1962), in an intensive study on the combining ability of inbred corn lines as influenced by population density, used three lines from a group whose maximum yield was attained at 20,000 plants per acre, the low group, and three lines whose maximum yield was attained at 28,000 or more plants per acre, the high group. The general and specific combining abilities were appraised in a modified diallel cross in a number of different planting densities. The high group was superior at both low and high population densities, while the low group did well only at low densities and suffered a decline in yield as population was increased. The high group showed no yield depression up to 28,000 plants per acre after which yield declined slightly at 32,000 plants per acre, the highest population. The relative rank of individual lines was the same from year to year and across population densities with only one single exception. The mean yields of low x low crosses increased from 12,000 to 24,000 plants per acre and then dropped sharply. The high x high crosses increased to 28,000 and then leveled off to 32,000 plants per acre. The low x high showed an interesting heterotic effect, being superior to low x low and high x high at the four highest rates.

Russell and Teich (1967) studied four groups of lines selected from M14xC103 that may be described as follows: groups 1 and 2, lines selected by testcross performance in low and high plant densities, respectively, during three successive generations; groups 3 and 4, lines selected by visual discrimination among and within inbred progenies in low and high plant densities, respectively, during three successive generations. The four groups of lines were compared for hybrid performance at five stand levels for two years. The tester parent plants used were WF9xI205, the single cross used as tester in the development of lines in groups 1 and 2, and IA4810, an unrelated double cross. Yields averaged over five plant densities at three locations for two years were 60.7, 61.6, 57.9, 59.5, and 55.8 quintals per hectare for groups 1, 2, 3, 4, and testcross of the parental single cross M14xC103, respectively, when WF9xI205 was used as the tester. When the comparison was made across the population densities 12, 16, 20, 24, and 28 thousand plants per acre, the highest average yields were obtained at the 16,000 population in six environments, the 20,000 population in two environments, and the 12,000 population in two environments. In most environments, the yield decrease at the 24,000 and 28,000 population levels was sharp. Yield differences among population densities were highly significant. The yield trends were not consistent among environments as indicated by the highly significant mean square for densities x environments. The authors indicated that with the WF9xI205 tester, all groups of lines had some yield gain when compared with the testcross of M14xC103. The gain was highly significant for groups 1, 2, and 4 but not for 3. The gain for group 4 was not significantly different from groups 1 and 2. The WF9xI205 testcrosses of the inbred selections indicated that visual selection at a low plant density was less effective than visual selection at a high plant density in eliminating lines that would be susceptible to barrenness. With unrelated tester IA4810, group 4 had the greatest gain and group 3 showed a loss, but none of the group differences with the testcross of M14xC103 were significant.

Russell (1968) crossed 10 single-ear and 10 two-ear inbred lines of maize with two testers, a one-ear single cross, 1 x 1, and a two-ear single cross, 2 x 2, and evaluated for grain yield at four plant population densities at two locations for three years. The plant densities were 29,000, 38,700, 48,400, and 58,000 plants per hectare. The components of variance for hybrids showed that, in general, as the stand levels increased, the variance among hybrids increased. However, as the stand levels increased the error variance also increased. He concluded that there was no consistent relationship between stand levels and heritability values. The average mean yields over all environments were 66.0, 70.4, 69.9, and 67.7 q/ha for the densities 29.0, 38.7, 48.4, and 58.1 thousand plants per hectare, respectively. The average mean yield ranged from 59.9 to 80.6 q/ha over the six environments. From these results the author concluded that he could not make a recommendation of the optimum stand level for yield evaluation.

Russell (1969) had 19 S_3 lines of corn that survived selection through three successive generations, S_0, S_1, and S_2, on the basis of testcross performance in a low or a high plant density. The lines were selected from Low Ear Synthetic. In the first generation, testcrosses of 94 S_0 plants were evaluated. The 19 S_3 inbred lines could be classified into three groups: group 0, five inbred lines selected on the basis of testcross performance at both low and high plant densities; group 1, seven inbred lines selected on the basis of testcross performance at low plant density; and group 2, seven inbred lines selected on the basis of testcross at high plant density. Two testers were used in the final study: a double-double cross (DDC), used in the selection of the lines, and an unrelated single cross (SC). The testcrosses were grown in 32,200 (low), 48,300 (medium), and 64,400 (high) plants per hectare in five environments.

With the SC tester there was no yield improvement of inbred selections over the Low Ear Synthetic. However, the average yield performance of the inbred selections with the DDC tester was superior to that of the parental source, although the improvement was in groups 1 and 2 and not in group 0. The average mean yields were 51.9, 55.0, 58.2, and 50.1 q/ha for testcrosses of groups 0, 1, 2, and the parental synthetic, respectively. He indicated that, although the yield improvement was greater in group 2 than in group 1, the difference was not significant. On the other hand, the relative yield of groups 1 and 2 across stand densities is described best by the linear regression coefficients. The groups yielded nearly the same at the low density, but from density 1 to density 3, group 1 had a 13.6 percent decrease and group 2 had only a 1.2 percent decrease, thus giving group 1 a greater negative b_{ℓ} value. The difference in performance of the two groups across the stand densities was highly significant. Yield differences among testcross in all groups were highly significant. The testcross x environments interaction mean square was much greater for group 1 (232.25) than for group 2 (53.50). The interaction of environments x densities-linear x among crosses in group 1 also was highly significant, but in group 2 the interaction was not significant. He concluded that the stability of yield performance among lines was better in the high-density group than in the low-density group.

Keeping in mind the differences of the major types of gene action affecting the different characters in the different field crops, it seems worthwhile to look at similar studies conducted with other field crops.

Gotoh and Osanai (1959) compared selection for yield under different densities of progenies of wheat crosses. They concluded that the higher efficiency which they had in the wide spacing was due to the increased phenotypic variation. This was in contrast to the findings of Guitard, Newman and Hoye (1961) who found that selection from space planted, early generation hybrid wheat, oats, or barley was less efficient than selection in dense seedings.

Correlations among agronomic and seed characters and seed or oil yield in soybeans have been reported by several workers. The relationship of seed characters to oil and protein content was studied in 195 varieties by King and Wang (1935); seed characters of F_2 plants from three crosses among (*Glycine max*) strains were evaluated by Viljoen (1937); F_2 plants and their F_3 progenies from *G. max* by *G. ussuriensis* were studied by Weber and Moarthy (1952). The most consistent relationship in the four studies is the negative correlation between oil and protein content which is in agreement with the earlier finding by Bordakou (1933).

Ross (1939) studied the correlation between several agronomic characters of sunflowers (*Helianthus annus L.*) and yield of seed and oil content. A significant, positive correlation was obtained between the percent of oil in the seed and the yield of seed produced. On the other hand, a highly significant, negative correlation was reported between the seed yield and characters, number of branches, number of leaves, days to blooming, and number of heads per plant. The author indicated that a nonsignificant relationship was observed between oil content of the seed and the characters, number and area of leaves, diameter of main heads, number of branches, days to blooming, and number of heads per plant. The author suggested that the taller, nonbranching types are worthy of special consideration as basic breeding material in breeding sunflowers for high yielding varieties of high oil content.

Putt (1943) reported a two-year study on the relationship between sunflower inbred lines yield of seed and plant characters, days from seedling to maturity, plant height, stem diameter, and diameter of the main head. Positive, significant correlations between seed yield and these four characters were obtained. However, the oil content of the seed did not correlate significantly with any of these five characters. Negative correlations, but not significant, were obtained between oil content and seed size and weight per bushel. The multiple correlation between oil content and the characters, days to maturity, plant height, stem diameter, head diameter, seed yield, 1000-seed weight, and percent of kernel was 0.599. Most of the variability accounted for in oil content was due to kernel content. The author concluded that selection of large heads and large stems will aid greatly in the development of lines of high oil content.

Russell (1952) studied the interrelationship of seed yield, oil content, and several agronomic characters in sunflower inbred lines and their topcrosses for two years. He reported highly significant, positive correlation coefficients in both years for the characters, days to flower, height of plants, and rust rating and, in one year, for head diameter and percentage of lodged plants of the inbred lines and the same characters in their topcrosses. Nonsignificant correlations were found between ten plant characters of the inbred lines and their topcrosses with the variety Sunrise. Oil content and kernel content had a positive, highly significant correlation in the inbred lines during the two years of the test and in the testcrosses only during the second year. The correlation between percent of oil in the seed of inbreds and in the seed of their topcrosses was positive and highly significant in the second year of the study.

Johnson (1932) reported a two-year study of the correlations between agronomic and compositional characters in flax. He showed oil content of seed from 46 strains of flax to be positively correlated with size of seed, lateness of maturity, and number of days from bloom to maturity. The three agronomic characters were found to have a high degree of association among each other as well. Partial correlation shows that when either date of maturity or number of days from bloom to maturity was held constant, the correlation between oil percent and seed size attained the one percent level of probability (from +0.49 to +0.70), whereas neither maturity nor duration of seed development period was significantly correlated with oil percentage when adjustment was made for seed size.

Pawlisch and Shands (1962) indicated that when the breeding behavior for bushel weight, yield, height, heading, and maturity dates of two oat crosses was studied, the only consistent correlation seemed to be positive associations between bushel weight and yield, height and heading date, and yield and height.

George, Averly, and Casady (1969) reported a study on the interrelation among agronomic characters in grain sorghum. They pointed out that the genotypic correlations among 12 characters were estimated in segregating populations and in pure lines of grain sorghum (Sorghum bicolor Moench). Grain yield was positively, significantly correlated with head weight, kernel number, half bloom date, and leaf number; but negatively correlated with germination percentage and protein percentage. The inverse relationships between kernel weight and kernel number and between kernel weight and head number per plant may arise from developmentally induced relationships or be genetically dependent. Head weight and half bloom date are considered best indicators for yield, while germination percentage may be of value as an indicator for protein content. Magnitudes of the estimates of expected progress in improving yield by selecting for characters other than yield appear to be greater than those for protein, indicating that direct selection for protein may be more effective in improving protein content.

The failure of stalks to produce ears, or barrenness, is an important factor for differentiating among hybrids for yield performance at high stand levels. Barrenness in inbred lines results because of delayed silk emergence relative to pollen shedding, and it is expected that inbreds transmit this character to hybrid combinations. Consequently, selection for inbred lines that do not have delayed silking should give genotypes that have one required factor for yield performance at high stand levels.

Sass (1962) indicated that a revival of interest in the development of axillary buds of maize was due in part to agronomic considerations, in particular the production of commercially valuable hybrids that produce more than one harvestable ear on a plant. He indicated the need to search for multiple ear types of maize as a possible source of the desired germplasm. To obtain needed information he suggested the examination of the shoot apices, especially the apices of the axillary buds, as well as all meristematic apices of the plant.

Sass and Loeffel (1959) compared single crosses and inbred lines of maize for the initiation and development of inflorescences, in particular the response to plant population levels with respect to stalk barrenness. They indicated that competitive pressure does not produce a marked reduction of ear elongation, ovary development, or silk elongation until approximately 74 days after planting. They concluded also that barrenness is the result of failure of silk emergence during the pollen shedding period rather than the failure of formation of floral organs. In a subsequent study of a one-ear type hybrid, Sass (1960) ascribed the general failure of a corn plant to develop the second ear to factors associated with competition prior to and after anthesis.

Comparative studies by Sowell, Ohlrogge and Nelson (1961) of the growth and fruiting of the compact mutant type of inbred Hy and its normal counterpart suggested that barrenness was caused by competition between vegetative growth and ear shoot development for the limited resources of the plant. Compact mutant types were able to produce grain under conditions of population stress because of the termination of vegetative growth at an early stage of plant growth. Normal inbred Hy does not cease vegetative growth at the time of ear shoot development, thus causing barrenness in dense populations.

Collins (1963), in a thesis research at Iowa State University, studied the morphological development of the tassel and potential ears. His research germplasm included: 1) inbreds R71 and B60 which consistently produce two ears per plant; 2) inbreds Hy and C103 which consistently produce one harvestable ear; and 3) single crosses involving all these lines, thus giving 1 x 1, 1 x 2, and 2 x 2 types. Plant densities were 29,650 plants per hectare. His results showed that the four inbreds may be ranked for expressivity of two-ear production from highest to lowest as follows: R71, B60, Hy, and C103. The performance of the inbreds in single crosses indicated that this ranking is correct and that two-ear development appears to be affected by a number of recessive genes. The single-ear inbreds and their single cross had a retarded growth rate of the second ear which became evident about nine days before silk emergence. These genotypes did not produce second ears. By contrast, the second ear development of R71, B60, and their single cross was similar to the top ear, and these genotypes usually produced a second ear. He concluded that the degree of second ear development in the pre-silk emergence period is an aid to detecting potential two-ear types, particularly if a harvestable second ear is not produced because of some unfavorable climatic condition. In later research, Russell (1968) found that the incidence of barren stalks was fourfold greater for a (1 x 1) x 1 type than for a (2 x 2) x 2 type at a stand level of 58,100 plants per hectare. Thus, it appears that selection for the strong second ear development may give parental material that will resist barrenness under stress conditions.

Further evidence of greater flexibility in ear development of a 2 x 2-type as compared with a 1 x 1-type was shown by Collins and Russell (1965). When the top ear shoots of 1 x 1-type crosses were covered to prevent pollination, the second shoots did not develop into harvestable ears. However, for a 2 x 2-type cross with similar treatment under the same environmental conditions, the second ear shoot did develop a harvestable ear. They suggested that selection for second ear development may be valuable in selection for stability of production.

Russell and Teich (1967) studied the pre-silk cob growth rates on five groups of inbred lines that had been developed by different selection procedures. Three groups had been selected on the basis of high testcross performance: group 1 at a low stand level, group 2 at a high stand level, and group 0 at both low and high stand levels. Two groups had been selected on the basis of visual appearance of the inbred progeny, group 3 at a low stand level and group 4 at a high stand level. The cob growth rates were made during the 15 to 18 days before silk emergence. The cob growth rate data were converted to a semilogarithmic form, log ear length versus time, and linear regression coefficients were calculated for each group.

Since these lines were studied for testcross performance, Russell and Teich were able to make some comparisons between the cob growth rates and testcross yields. Comparing b values for the five highest and five lowest combining lines, the growth rates were greater for both cobs of the high combining group; however, the difference was greater for the second cob. Group 0, which had the highest combining ability among the groups, had the highest b value among the groups for the second cob. The data suggest a relationship between combining ability and growth rate of the second cob. Top cob lengths at silk emergence were similar for groups 1, 2, 3, and 4; second cob lengths at silk emergence were greater for visually selected groups 3 and 4 than for testcross selected groups 1 and 2. There was no correlation between top cob length and hybrid yield of the inbred selections, but between the second cob and hybrid yield the positive correlation was highly significant, although too small to be of predictive value.

Since Shull's (1910) first inbreeding experiments, various procedures of breeding methods have been used by maize breeders, but the successful development of improved hybrids or synthetic populations of maize depends upon the precise evaluation of the inbred lines developed. Visual evaluation of the inbred phenotypes had been used until Davis (1929) suggested the use of a topcross to measure the combining ability of inbred lines. Topcross evaluation was normally deferred until a high degree of homozygosity had been obtained. There has been disagreement among breeders on the efficacy of visual selection in inbred development to improve yield performance in hybrid combinations. Positive correlations between vigor characters of inbred lines and their hybrid yield performance have been shown by Jenkins (1929), Hayes and Johnson (1939), and Russell and Teich (1967). On the other hand, Brown (1967) reported evidence that visual ratings of inbred lines are not satisfactory criteria for hybrid yield performance. Jenkins (1935) proposed early generation testing, and a study conducted by Lonnquist (1950) made breeders aware of the value of the topcross for early identification of superior germplasm.

Davis (1934) reported a study in which he crossed S_2 inbred lines to an unrelated open-pollinated variety of corn. He found a positive, significant phenotypic correlation coefficient between yield of the testcrosses and the average yield of the first and second generations of inbreeding. On the other hand, he reported a negative, but nonsignificant, correlation between yield of the testcrosses and the percentage of barren and diseased plants in the inbred parents. He concluded from the study of these correlations that, for the material studied, the average yield of the first and second inbred generations was the most dependable basis for selection of inbred lines. He suggested that the performance of the cross of inbred lines with a variety could be used as a means for preliminary screening of inbred lines.

Jenkins (1935) investigated the effectiveness of selection by topcross and the possible influences of chance changes in combining ability during inbreeding. The progeny of random ears from two open-pollinated varieties were topcrossed, two sister lines from each family in each generation. One of these sister lines was the selected line and the other, the discarded line. Selfing was continued until S_8. Seven families from the variety Iodent and five families from Lancaster were represented in yield trials by the selected line of each generation. The trends from S_1 to S_2 were upward in Iodent and downward in Lancaster, but from S_2 to S_8 the average combining abilities of the seven Iodent families were constant while Lancaster showed an erratic upward trend. The analysis of variance showed that the variation due to families was significantly larger than due to interaction between families and generations. For this reason the author concluded that families had acquired their individuality as parents of topcross very early in the inbreeding process.

Richey (1945) reanalyzed Jenkins' (1935) data on the theory that selection might have been effective in some families and ineffective in others. Averaging over families could have obscured these results. To smooth the data without masking trends, he averaged yields of individual families by two generation periods. This did reveal some lack of correspondence between early and later generation performance. High performance at fixation originated with a trend which began at S_4-S_5. Because of this he proposed that selection should be delayed until S_4, after which testcross performance should be used for selection among families, and visual selection for discrimination within families. In a later study in 1947 he indicated that inbred performance of the S_3 or S_4 lines was about as good a criterion of combining ability as topcross performance and at a much lower cost.

On the basis of topcross performance, Lonnquist (1950) reported high and low combining S_1 plants were chosen to initiate the two directions of selection for yield within each S_1 progeny. The selfed progeny were grown ear-to-row, and selection within the S_2, S_3, and S_4 continued in like manner. In 1948 the topcrosses of selected high and low lines were tested in a single experiment. Results indicated that selection for both low and high combining ability for the several generations starting with the S_1 families was successful. He concluded that, although selection based upon topcross performance could greatly modify the combining ability of S_1 lines in subsequent selfed generations, early testing of S_1 lines provided a better sample of material in which to inbreed than a random sample from the same population.

Sprague and Miller (1952) evaluated the effectiveness of visual selection for combining ability in a population density of 12,000 plants per acre. Two sets of 50 plants were selected through five generations, and the resulting inbred lines crossed in all possible combinations. Because very little change in combining ability was observed across generations, they concluded that visual selection during inbreeding had no effect on general combining ability.

Wellhausen and Wortman (1954) reported on the relative combining ability of selected S_1 lines and of S_3 lines derived from them when crossed with a general combining ability tester. They concluded that inbreeding accompanied by visual selection in selected adapted S_1 lines offered very limited opportunities for improvement. While general combining ability is of considerable importance in a breeding program, it seemed desirable to know to what extent cycles of strong visual selection would affect yield in specific combinations. They reported one year's data from an experiment designed specifically to study this problem. This experiment included comparisons of 45 crosses of S_1 x S_1 lines with 45 crosses of derived S_4 lines. They reported an average net increase attributable to visual selection of 11.2 percent. Division of the crosses into three groups, Local x Local, Local x Introduced, and Introduced x Introduced, led them to the tentative conclusion that visual selection was probably ineffective in the improvement of the combining ability of local, high combining S_1 lines, but was effective in favorably changing S_1 lines from introduced varieties. However, there were only three crosses in the Local x Local classification.

Osler, Wellhausen and Palacios (1958) reported that three separate experiments were conducted to determine the value of visual selection for improving combining ability in specific hybrid combinations and to determine if adaptation of the lines involved had any effect upon this selection. The experiments included 134 pairs of crosses: 20 Local x Local, 77 Local x Introduced, and 37 Introduced x Introduced. One cross within each pair was of S_1 lines while the other was of derived advanced lines. Field data were obtained on ear and plant appearance and yield. The single crosses x generations interaction was highly significant in 1951 and 1955, indicating that in these two years at least some of the single crosses differed in performance as the lines involved varied in degree of inbreeding. The variation associated with generations was highly significant within each of the three years. On the average, the single crosses involving S_1 lines were different from the crosses involving advanced lines. When the same error terms were used to test the variation associated with single crosses, significant differences were found between at least some of them in each of the three years. The differences in favor of the advanced lines crosses were 4.4, 6.8, and 9.0 bushels per acre for the LxL, LxI, and IxI types, respectively, indicating that visual selection was more effective in the introduced lines than in the local lines.

The effectiveness of visual selection for combining ability during inbreeding of maize has been a subject of disagreement among breeders. Jenkins (1929) and Sprague and Miller (1952) deny any influence of visual selection during inbreeding on the general combining ability of selections. On the other hand, Hayes and Johnson (1939) and Osler, Wellhausen and Palacios (1958) support the efficacy of visual selection on combining ability. Since visual selection during inbreeding is a special case of phenotypic selection, the relationship between S_1 yield performance and general combining ability as tested by topcross (or testcross) performance is of interest to many breeders.

Genter and Alexander (1962) compared the performance of S_1 lines and testcross progenies of maize using two single cross hybrid testers. They selfed 51 S_0 plants from each of the following synthetic varieties: Corn Belt Southern Synthetic, Virginia Long Ear Synthetic, and at the same time crossed them to two single crosses. The authors indicated that, contrary to expectancy, the S_1 progeny performance was much more consistent under different environments than testcross performance. They also indicated that the data provided evidence that selection of lines based upon S_1 progeny performance should be more reliable than selection on the basis of testcross performance. However, they indicated that the ultimate value of S_1 progeny evaluation will depend largely upon their effectiveness in shifting the gene frequencies in the desired direction.

In a later study (1966) Genter and Alexander reported the results of two completed cycles of recurrent selection on 153 S_1 inbred lines derived from the Corn Belt Southern Synthetic (CBS) variety. Selection was based on S_1 progeny yield in one program and on testcross yield in the other. S_1 yield tended to increase with selection both for progeny yield and for testcross yield. The mean S_1 yield increased 1,000 pounds per acre (31.4 percent) in two cycles of selection for S_1 yield and 570 pounds per acre (17.9 percent) in two cycles of selection for testcross yield. The correlation between the yield of the 153 S_1 lines from CBS synthetic and the corresponding yield of their testcrosses was highly significant and six of the ten most productive lines were among those that produced the ten highest yielding testcrosses. The authors also reported that lines derived from the most productive S_1 progenies were most frequently maintained under visual selection and, in general, discarding in each generation tended to be most severe among those progenies derived from lower yielding S_1 lines. The authors concluded that selection for vigorous inbred lines *per se* may be effective in selecting for general combining ability. However, they pointed out that there was, sometimes, considerable difference between S_1 lines that appeared to be vigorous and those that were high in yield. They also stated that yield in corn is very difficult to evaluate visually.

Koble and Rinke (1963) tested random S_1 lines from a synthetic corn variety for yield performance as S_1 lines and in topcross tests with related and unrelated testers. They reported that the relationship between the S_1 line performance and either of the two topcrosses was generally as high as, or higher than, the relationship between the two topcrosses themselves. They concluded that, on the basis of these tests, selection based on S_1 performance might be used to replace the more expensive and time consuming method of topcrossing.

Genter (1963) suggested that if heterosis results primarily from "additive and dominant gene effects, progeny performance in early generation inbred lines should evaluate their general combining ability better than testcrosses." This led to a study reported by Lonnquist and Castro (1967) in which an intra-population genetic variance was obtained using design I matings in high and low selected S_1 lines (F_2 populations) representing extremes from a total of 169 $Krug_{III}$ synthetic lines. The basis of evaluation was: a) S_1 *per se* {1. High (HS_1), 2. Low (LS_1)}; b) testcrosses with the parental population {1. HRTX, 2. LRTX}; and c) testcrosses with an unrelated population {1. HUTX, 2. LUTX}. The experiments were grown over a two-year period. The authors indicated that there appeared to be more additive than nonadditive genetic variance for yield within lines selected as high-yielding in testcross performance, whereas the reverse was true in those selected as high-yielding on the basis of line *per se* performances. On the other hand, low selected S_1 lines exhibited, generally, more nonadditive genetic variance. Standard errors were of such magnitude as to preclude establishment of clear-cut differences among variance components. Performance trials of the derived synthetics failed to show superiority for any of the three line evaluation procedures.

Lonnquist and Lindsey (1964) presented more information on the predominant types of gene action prevailing in the two types of line evaluation, lines *per se* and topcross to an unrelated tester. The high- and low-yielding lines from each of the two evaluation procedures were selected and crosses between and within groups were obtained. Results were presented suggesting that selection for yield based upon these two methods were dependent upon different types of genetic effects. Intercrosses of lines selected from topcross performance resulted in a yield trend suggesting overdominant gene action, whereas the line _per se_ suggested additive type of gene action. Although these authors did not find a definite relationship between line _per se_ and testcross performance developed from the same population, $Krug_{III}$ synthetic, they recognized that the use of a line test would be a more effective evaluation procedure because, with a wider range of phenotypic expression for yield, it would permit a better chance of discrimination among line genotypes.

In a later study by Lonnquist (1968), a total of 169 S_1 lines out of $Krug_{III}$ synthetic were evaluated by three different methods: line _per se_, testcrosses to an unrelated tester, and testcrosses to the parental population. In each evaluation procedure, the lines exceeding the test mean by one or more phenotypic standard deviations were selected. The selected S_1 lines in each series were intercrossed to form the next cycle populations. In the line _per se_ test, 19 lines were selected to form the next cycle ($K_{IV}A$) population. Testcrosses to the unrelated tester resulted in selection of 25 lines to form K_{IV}-2 and with the parental tester 22 lines were selected to form the K_{IV}-3 population. Only two lines were common to all three groups. The three highest- and three lowest-yielding from each of the three evaluation series were used to study their intercross behavior. The 18 lines were intercrossed. Composites of HH, HL, and LL crosses within each set of six lines and crosses between sets (H_iH_j, H_iL_j, L_iH_j, and L_iL_j) provided the material for test evaluation in 1965-66. In each evaluation series the superior lines had been selected to form new cycle populations. These populations, Cycle IV, together with parental, K_{III} synthetic were included in the performance trials.

The results indicated that the LL, HL, and HH groups from line per se selections exhibited a linear trend for yield. Selection on the basis of an unrelated tester resulted in the HL group $\geq$ the HH group where the values of 7.93 and 7.84 were obtained for yield in tons per hectare for HL and HH, respectively. Intercrosses of lines selected on the basis of the parental population as the tester exhibited a linear yield trend but with evidence of partial dominance for high yield. The highest yields resulted from intercrosses of lines selected on the basis of performance in testcrosses with the parental population. The author also indicated that the derived population based upon selection from testcrosses with the parental population (K_{IV}-3) exhibited a 15 percent increase in yield relative to K_{III} synthetic. The derived population based on lines per se selection resulted in a four percent gain in yield, whereas no gain resulted from selection based upon evaluation in testcrosses with the unrelated tester parent.

Torregroza and Harpstead (1965) and Nanda (1966) agreed that when inbred line per se evaluation was compared with the testcross evaluation procedures, S_1 line per se gave the most consistent results. Nanda added that the performance of inbred lines themselves gives a good indication of the performance of their hybrid progenies for relatively simply inherited traits. Although he does not define which are those so-called simply inherited traits, it is clear that he could be referring to characters other than grain yield and shelling percentage.

Duclos and Crane (1968) intercrossed 45 introduced maize strains, two Northern U.S.A. single crosses, and their double cross, to form a synthetic variety which was randomly mated for three generations. Randomly chosen S_0 plants were selfed and crossed to a double cross tester. The top yielding 11 percent of the S_1 lines based on S_1 performance and top yielding 11 percent of the S_1 lines based on topcross performance were developed into two subsynthetics in which random mating was practiced for three more generations. In the top yielding lines based on each of the two criteria of selection, only five lines out of a possible 26 were found to be common to both groups.

A phenotypic correlation S_1 vs topcross of 0.42 for yield was highly significant. The authors concluded that this result indicates a relationship between the two evaluation procedures, but this value is too small for prediction purposes. They indicated that one would expect selection based on S_1 line performance to emphasize almost totally additive genetic effects, whereas selection based on topcross performance would be expected to emphasize additive genetic effects and some nonadditive effects.

The authors added that, in the following cycle, mean yields were significantly higher in the S_1 progeny from the synthetic based on S_1 progeny performance than from the synthetic based on topcross performance. Conversely, mean yields were significantly higher in the topcrosses from the synthetic based on topcross performance than from the synthetic based on S_1 line performance. They also indicated that when genotypes selected on the basis of S_1 line performance were tested later as S_1 lines, an 8.8 percent gain relative to the checks was observed. When these same genotypes were tested in topcrosses to a common tester, no gains were realized. Similarly, when genotypes were selected based on topcross performance and tested later in topcrosses, a gain of only three percent relative to the checks was obtained. The S_1 lines after a cycle of selection showed five percent increase over the original S_1 lines. These observations were interpreted by the authors as indicating more improvement may be obtained by selection based on S_1 progeny tests. This interpretation may be questioned since the mean of the S_1 progeny was low and considerable latitude for improvement was available.

Duclos and Crane propagated the next generation of each subsynthetic by intermating the top-yielding 21 percent based on each evaluation method. Samples of seed were drawn from each generation of subsynthetic and parent synthetic and tested at two locations. These tests indicated that a highly significant yield improvement was made with the first cycle of selection by both methods of evaluation, but there was no significant difference between the two methods.

Keeping in mind the differences of the major types of gene action in crops with different mating systems, self-pollination versus cross-pollination, it would be worthwhile to look at the effectiveness of visual selection and early testing in breeding programs in other field crops.

Kwon and Torrie (1964) found highly significant correlations between visual scores and actual yields in two soybean populations.

Frey (1962) studied the effectiveness of visual selection upon yield in two oat crosses. The progenies from F_2 oat plants classified as good, random, or poor by visual observation were compared for yielding ability. In one cross the mean yields for the three categories were approximately equal, whereas in the other one the poor selection category yielded lower than the random or good categories in 1956, but not in 1957. The effectiveness of visual selection was further evaluated by classifying single plants and progeny rows in the F_5 generation as good, random, and poor. Again, all categories based on F_5 single plants yielded approximately the same; however, the lines derived from good F_5 progeny rows not only yielded more than their poor and random counterparts, but they averaged two bushels higher than the F_2 derived lines from which they were selected. The author stated that the yielding capacity of oat lines appeared to associate with criteria used in visual selection. However, the phenotypic expression of single plants was so confounded with environmental influence that visual selection based upon them was ineffective, but was effective when based upon progeny rows.

Atkins (1964) reported that 25 plants were taken at random from the F_3 of a barley variety cross to compare with 25 plants selected visually as good plants and 25 plants selected visually as poor plants on the basis of phenotypes. The yield trials of the F_5, F_6, and F_7 of these three groups (good, random, and poor) follow the same pattern as expected. There was a significant difference between the good group and the poor group. The good group yielded less than a bushel per acre higher than the poor group and the yield difference was only 39 pounds per acre between the good and the random group. The author concluded that visual selection on a single plant basis was not pracatical, except perhaps in the identification of low yielding lines.

In an early generation testing study in soybeans by Weiss, Weber and Kalton (1947), they indicated that seed yield of spaced F_1 plants was of limited value in predicting the yield potentialities of 17 soybean crosses studied. Means of individual plant determinations on spaced F_2 plants contributed significant intercross information on yield, maturity date, and lodging resistance of final selections evolved from the 17 crosses. The bulk population tests gave reasonably accurate evaluation of crosses for potential lodging resistance and height of subsequent selections. They were found of little value in the prediction of potential yield or date of maturity. Crosses responded differentially when tested in the bulk F_2 to F_5 generations in all characters studied. They also added that natural selection was of sufficient magnitude to give extremely irregular advanced generation curves.

Pawlisch and Shands (1962) studied the breeding behavior for bushel weight, yield, height, heading, and maturity dates in early generations of two oat crosses. The statistical analyses indicated that some lines were still segregating for heading date, yield, and height after three generations of selection, F_2, F_3, and F_4. After two generations of selection, segregation for bushel weight and maturity date was not statistically detectable.

Schaaf (1968) reported that open-pollination progenies were used to study the effectiveness of phenotypic selection for seed characteristics in crested wheat-grass (Agropyron desertorum (Fisch. esc. Link) Schult) maternal parentage. He indicated that, despite significant ($p < 0.001$) parent-progeny correlations of 0.517 for seed yield and 0.797 for seed size, single character selection among spaced plants did not positively identify the most desirable genotypes for either yield or size of seed.

III. MATERIALS AND METHODS

The inbred lines used in this thesis research were selected from a group of 61 lines developed from M14xC103 for a previous study on breeding methods. The development and evaluation of these 61 lines have been described in detail by Russell and Teich (1967). On the basis of the breeding procedures, these lines can be described in four groups as follows:

1) Group 1. The lines were selected in three successive generations, F_2 to F_4, on the basis of high testcross performance at a low stand level, 38,700 plants per hectare.
2) Group 2. The lines were selected in three successive generations, F_2 to F_4, on the basis of high testcross performance at a high stand level, 58,100 plants per hectare.
3) Group 3. The lines were selected in three successive generations, F_3 to F_5, on the basis of the phenotypic appearance of the inbred progeny at a low stand level of 29,000 plants per hectare.
4) Group 4. The lines were selected in three successive generations, F_3 to F_5, on the basis of the phenotypic appearance of the inbred progeny at a high stand level of 58,100 plants per hectare.

The tester parent for groups 1 and 2 was a single cross, WF9xI205. The beginning basis of all selections was 138 F_2 plants of M14xC103 and, after final selection in the four groups, there were 16 lines in each group. Since three selections were common to groups 1 and 2, actually

29 lines were selected on the basis of testcross performance. The evaluation data of Russell and Teich (1967) suggested that further studies of some of the inbred selections would give information of value to a maize breeder. Consequently, two groups of 20 lines were selected for further study.

The first group of 20 inbreds was selected to study the relationships in testcrosses of important plant and ear characters to grain yield and to determine the effects of varying plant stand densities on these relationships. Also, the inbred lines per se were to be evaluated for growth rates of the first and second cobs during approximately 15 days before silk emergence. These growth rate data were to be related to the hybrid performance.

The pedigrees of the inbred selections and the testcross yield data taken from Russell and Teich (1967) are shown in Table 1. Data for the testcrosses of M14, C103, and M14xC103 are included. The first ten lines have either high mean yields or positive regression coefficients, or both. The second group of ten lines all have high negative regression coefficients because of much reduced yields at the highest stand level as compared with the lowest stand level. At the lowest stand level, the average yields of the two groups are nearly equal.

Grain yield is the product of number of ears per plant, ear length, ear diameter (which involves kernel row number, kernel depth, and cob diameter), and kernel weight. If further experimentation of these testcrosses can obtain results similar to the data in Table 1, the data on yield components should give information on the relative importance of

Table 1. Entries (with yield data from Russell and Teich, 1967) for the study of the relationship between yield components and final yields, effects of stand levels on these characters, and the cob development in inbred parents and its relationship to hybrid performance

Entry no.	1963 nursery row no.	Pedigree no.	Yield, cwt per acre at population density (x 1000) 12[a]	18	24	Mean	b_{ℓ}
01	1882	1505- 14- 11	62.4	67.6	62.2	64.0	-0.10
02	1894	1558- 15- 62	60.0	66.9	61.0	62.6	+0.50
03	1900	1576- 56- 66	60.9	66.0	61.4	62.8	+0.25
04	1910	1618-117- 49	64.0	68.1	64.2	65.4	+0.10
05	1923	1576- 9-170	57.1	65.2	57.2	59.8	+0.05
06	1938	1617-247-164	59.8	66.7	59.9	62.1	+0.05
07	1861	1606-1-1-1	62.8	73.9	66.0	67.6	+1.60
08	1862	1635-1-1-2	65.4	69.2	61.4	65.3	-2.00
09	1874	1570-1-1-1	56.6	61.0	59.9	59.1	+1.65
10	1878	1602-2-1-1	64.4	71.7	69.9	68.6	+2.75
11	1892	1555-110- 92	58.9	59.5	47.2	55.2	-5.85
12	1908	1612- 44- 21	63.3	63.9	52.1	60.4	-4.60
13	1914	1636- 40-117	62.5	62.7	53.8	59.7	-4.35
14	1925	1578- 33-196	64.6	70.5	57.6	64.2	-3.50
15	1932	1526-253-127	59.7	62.5	50.5	57.5	-4.60
16	1853	1550-2-2-2	55.0	47.7	35.8	46.1	-9.60
17	1860	1604-2-2-1	61.1	60.6	52.4	58.0	-4.35
18	1870	1534-2-1-1	63.4	62.9	54.7	60.3	-4.35
19	1880	1632-1-1-1	66.0	70.2	57.8	64.6	-4.10
20	1881	1638-2-2-1	63.2	61.7	56.4	60.4	-3.40
21		M14	56.1	55.6	56.1	55.9	0.00
22		C103	55.0	58.1	50.2	54.4	-2.40
23		(M14xC103)	59.7	62.2	52.2	58.0	-3.75

[a]Number of plants per acre.

these components as causes for the variation in yields among the plant stand densities.

The second group of 20 inbred lines was chosen to determine the effectiveness of selection on the basis of testcross performance and phenotypic appearance of the inbred progenies to improve combining ability in three successive generations. The pedigrees of the lines selected and the testcross yield data taken from Russell and Teich (1967) are shown in Table 2. The first ten lines were developed on the basis of phenotypic appearance and include five lines with high testcross performance and five lines with low testcross performance. The second ten lines were selected on the basis of testcross performance and include five lines with high testcross performance and five lines with low testcross performance. Entries 1, 2, 3, 5, 7, 11, 13, 14, 16, 18, and 20 are in the group described previously. A study of the testcrosses of these selections and of their sources in preceding generations should reveal to what extent the differences shown in Table 2 resulted because of genetic differences present from the beginning in the F_2 generation or because of further genetic changes due to selection in the succeeding generations.

A. Field Procedures

1. Relationships between yield components and grain yield and effects of plant stand densities on these characters

Testcrosses of the 20 inbred selections and three checks, M14, C103, and M14xC103, were evaluated in split-plot experiments with five replications at Kanawha, Ames, and Ankeny in 1966, 1967, and 1968. The main

Table 2. Entries (with yield data from Russell and Teich, 1967) selected to study the effectiveness of visual and testcross selection to improve combining ability in three successive generations, F_2, F_3, and F_4

Entry no.	Pedigree of 3rd selection	Method of selection[a]	Yield cwt per acre at population density (x 1000) 12[b]	18	24	Mean	Group average	b_ℓ
01	1606-1-1	VS	62.8	73.9	66.0	67.6		+1.60
02	1635-1-1	VS	65.4	69.2	61.4	65.3		-2.00
03	1602-2-1	VS	64.4	71.7	69.9	68.6	66.1	+2.75
04	1620-1-1	VS	62.1	70.4	60.6	64.4		-0.75
05	1632-1-1	VS	66.0	70.2	57.8	64.6		-4.10
06	1524-1-1	VS	53.8	53.9	45.1	50.9		-4.35
07	1550-2-2	VS	55.0	47.7	35.8	46.1		-9.60
08	1574-2-1	VS	54.2	55.0	54.1	54.5	51.5	-0.05
09	1595-1-1	VS	55.8	56.5	46.7	53.0		-4.55
10	1511-1-2	VS	54.7	56.9	46.8	52.8		-3.95
11	1505- 14- 11	TC	62.4	67.6	62.2	64.0		-0.10
12	1581- 64- 67	TC	61.5	68.2	59.3	63.0		-1.10
13	1618-117- 49	TC	64.0	68.1	64.2	65.4	64.0	+0.10
14	1578- 33-196	TC	64.6	70.5	57.6	64.2		-3.50
15	1582-113-183	TC	63.9	66.7	59.8	63.5		-2.05
16	1555-110- 92	TC	58.9	59.5	47.2	55.2		-5.85
17	1559- 55- 64	TC	57.8	64.0	48.6	56.8		-4.60
18	1636- 40-117	TC	62.5	62.7	53.8	59.7	57.1	-4.35
19	1521- 52-153	TC	56.7	56.0	55.6	56.1		-0.55
20	1526-253-127	TC	59.7	62.5	50.5	57.5		-4.60

[a]VS = visual selection; TC = testcross selection.

[b]Number of plants per acre.

plots in the split-plot design were three plant densities (low, medium, and high) and the subplots were the 23 testcrosses. Plant densities were randomized among the main plots and within each main plot there was complete randomization of the testcrosses. WF9xI205 was the tester used.

Details of an experiment relative to number of hills and plots, plot size, and spacings are presented in Table 3.

Table 3. Details of field procedures for experiments of the testcross performance of 20 inbred lines and three checks in Table 1

	Plant densities		
	Low	Medium	High
Number of plants per hectare	30,998	40,787	59,470
Number of hills per subplot	9	12	17
Number of plants per subplot	18	24	34
Number of hills available for harvest	7	10	15
Number of hills to be harvested	5	5	5
Distance between hills (cm)	63.5	48.3	33.1
Subplot length (cm)	571.5	579.1	561.3
Distance between subplot (cm)	101.6	101.6	101.6

The data for number of plants per subplot, or per hectare, suggest that the increments between low, medium, and high densities are not equal. However, all data were to be recorded on a per-plant basis and the increments for area per plant are equal for low to medium and medium to high. Each subplot was a single row.

Seed was hand planted, dropping three kernels per hill, and plant stands were thinned later to two plants per hill. Extra hills per plot were planted to permit harvest of five competitive hills per subplot and, also, to have plot size nearly the same for all densities. However, at low density in 1966 it was apparent that seven interior hills per subplot were not sufficient to assure five competitive hills at harvest; consequently, low density was increased to eight interior hills in 1967 and 1968. Inter-hill spacings were achieved by using chains which were marked at the spacings shown for between hills at the three plant densities. At Ankeny in 1968 the distance between plots was 91.4 cm.

Seed bed preparation, fertilizer applications, and cultural practices were in accordance with those normally accepted as necessary to obtain above-average yields. Planting dates are presented in Table 4.

Table 4. Planting dates at each location for the testcross performance of 20 inbred lines and three checks in Table 1

	Years		
Locations	1966	1967	1968
Kanawha	May 6	May 3	May 13
Ames	May 4	May 18	May 15
Ankeny	May 2	May 12	May 11

At Ames in all years the date was recorded for a subplot when 50 percent of the plants had reached pollen shedding. Also, the date was recorded when 50 percent of the plants had silks emerged. Plant height to the collar of the uppermost leaf and height to the top ear node were taken on ten competitive plants per subplot for all experiments in late August or early September.

In each subplot ears were harvested from five two-plant hills that had at least one plant in each adjacent hill. Occasionally at the lowest stand level, particularly in 1966, fewer than five two-plant hills properly bordered were available, so a fewer number was harvested. A record was kept for each subplot of the number of barren stalks in the five hills. Second ears in each subplot were placed in a paper sack to keep separate from the top ears. All harvested ears were dried for 72 hours at 71 C and stored until further work was done.

Data obtained per subplot included ear length, diameter, cob diameter, kernel depth, number of ears, number of second ears, ear weight, grain weight, and weight of 300 kernels. Ear length measurements included the second ears. Ear length and diameter, ear number, ear weight, and grain yield were calculated on a per plant basis. Shelling percentage and number of seeds per plant were calculated. Also, from the flowering data recorded earlier at Ames, the value for silk emergence date minus pollen shedding date in each subplot was determined and coded by adding ten to avoid negative values.

Because of unfavorable growing conditions, experiments at Kanawha and Ankeny in 1966 and Ankeny in 1967 were discarded. Consequently, the six remaining experiments were considered as having been grown in six environments, ignoring years and locations.

2. Rate of cob growth for the top two ears during the 15-day period before silk emergence

The same 20 inbred lines used as parents of the testcrosses in the study described previously were studied for ear development in the period of approximately 15 days before silk emergence in 1966 and 1967. Inbreds M14 and C103 were included as checks.

In 1966, the 22 entries were planted in a randomized complete block design with five replications at Ames. Each plot consisted of a single row with 30 plants, one plant per hill after thinning, 33.8 cm between hills, and 101.6 cm between plots. The plant stand density was approximately 29,000 plants per hectare. In 1967, the plot size was increased to two rows with 30 plants per row and the same spacing between hills and rows as in 1966.

Seed bed preparation, fertilizer applications, and cultural practices were in accordance with those normally accepted as desirable for good corn husbandry, supplemented with hand hoeing for better weed control. The dates of planting were May 6 and 25 in 1966 and 1967, respectively.

Extraction and measurement of ear shoots were begun approximately 15 days before the anticipated date of silk emergence and were repeated every three days until each line had 50 percent or more of the remaining plants in the plot showing emerged silks. The extraction technique consisted of slitting both flat sides of the culm with a knife from top to bottom, stripping off the leaves to expose the top two prophylls, and opening the prophylls by a longitudinal incision to remove the cob. Cob measurements were made on three bordered plants per plot per date in 1966 and six bordered plants per plot per date in 1967. On the final date the top two cobs were measured on six plants in 1966 and on 12 plants in 1967.

3. Effectiveness of visual and testcross selections to improve combining ability of inbred lines in three successive generations

As shown in Table 2 and described previously, 20 lines in the F_5 seed generation were selected for this study. Also used were previous parental generations of each line, F_1, F_3, and F_4, the F_1 being the single cross M14xC103. Thus, there were 20 families with four generations per family. Each selection was crossed to WF9xI205, sampling at least 20 plants per generation of each line. Since at least 20 plants were sampled per generation to cross to WF9xI205, the F_3, F_4, and F_5 progenies are really representing the F_2, F_3, and F_4 generations. The experimental design for this study was a split plot in which the whole plots were families and subplots within a whole plot were the four generations of a family. Thus, there were 80 entries in an experiment. Whole plots and subplots within whole plots were completely randomized and there were three replications. The details of an experiment are presented in Table 5.

Table 5. Details of field procedures for experiments of the testcross performance of the 20 families in Table 2

Year and location	Distance between rows (cm)	Distance between hills (cm)	Final no. plants/ plot	Plants/ hectare	Date of plant- ing
1967					
Newell	101.6	50.8	46	55,700	May 16
Hampton	101.6	50.8	46	55,700	May 19
Ames	76.2	50.8	40	64,579	May 2
Ankeny	101.6	50.8	46	55,700	May 12
1968					
Kanawha	101.6	50.8	46	55,700	May 13
Martinsburg	96.5	45.7	46	65,122	May 3
Newell	101.6	50.8	46	55,700	April 30
Grundy Center	96.5	48.3	46	61,749	May 1
Ames	76.2	50.8	40	64,579	April 30
Ankeny	91.4	48.3	46	65,122	May 11

A subplot consisted of two rows with nine hills per row. Seed was hand planted, dropping three kernels per hill and thinning later to give the desired number of plants per plot. Seed bed preparation, cultural practices, and fertilization were those normally accepted as necessary for above-average grain yield.

Data obtained per plot at harvest were number of plants per plot, ear weight, and percent moisture in the grain. Ear weights were converted to quintals per hectare of shelled grain at 15.5 percent moisture using a common conversion factor for all plots. Because of unfavorable weather conditions, the experiments at Hampton and Ankeny in 1967 were discarded. Thus, the two remaining locations in 1967 and the six locations in 1968 were considered as eight environments, ignoring years and locations.

B. Statistical Procedures

1. Relationships between yield components and grain yield and effects of plant densities on these characters

The standard procedure for the split-plot design was used to analyze the data taken for yield and 12 other plant and ear characters. The model used for each character at each environment is as follows:

$$Y_1, Y_2, Y_3 \ldots\ldots Y_{13} = A(I) + B(J) + AB(IJ) + C(K) + BC(JK) + \varepsilon(IJK)$$

where

A = replication effect, $i = 1\text{-}5$

B = plant density effect, $j = 1\text{-}3$

C = entry effect, $k = 1\text{-}23$

AB = main plot error: error (a)

BC = plant density x entry interaction

ε = subplot error: error (b)

The assumptions for the model are that $\varepsilon(IJK) \sim N(0, \sigma_e^2)$; $AB(IJ) \sim N(0, \sigma_w^2)$. For the purpose of calculating the expected mean squares, plant densities and entries are considered fixed effects while replications are considered random. The source of variations, degrees of freedom, and expected mean squares for the analysis of variance are presented in Table 6.

Table 6. Source of variations, degrees of freedom, and expected mean squares for the analysis of variance of the individual environment for each character

Source of variations		Degrees of freedom	Expected mean squares
Replications	(r)	4	$\sigma^2 + t\sigma_a^2 + dt\sigma_r^2$
Densities	(d)	2	$\sigma^2 + t\sigma_a^2 + rt\kappa_d^2$
Reps x densities {error (a)}		8	$\sigma^2 + t\sigma_a^2$
Entries	(t)	22	$\sigma^2 + rd\kappa_t^2$
Entries x densities		44	$\sigma^2 + r\kappa_{dt}^2$
Error {error (b)}		264	σ^2
Total		344	

F tests for the different characters and their interactions were made according to the expected mean squares.

The combined analysis was done on the basis of the entry means; consequently, replication within environments sums of squares was estimated by pooling the sum of squares from the individual environments and divided by the number of replications. Plant densities and entries are considered fixed effects but environments are considered random. The model used for all characters studied except silking date, shedding date, and their differences is as follows:

$$Y_1, Y_5 \ldots\ldots Y_{13} = A(I) + B(IJ) + C(K) + AC(IK) + BC(IJK) + D(L) + AD(IL) + CD(KL) + \varepsilon(IJKL)$$

where

A = environments effect, $i = 1\text{-}6$

B = reps/environments effect, $j = 1\text{-}5$

C = plant densities effect, $k = 1\text{-}3$

D = entries effect, $l = 1\text{-}23$

The assumptions for the model are $BC(IJK) \sim N(0, \sigma_w^2)$; $\varepsilon(IJKL) \sim N(0, \sigma_e^2)$. The source of variations, degrees of freedom, and expected mean squares for the combined analysis of variance are presented in Table 7.

For silking dates, shedding dates, and their intervals there were only three environments; consequently (e) would be equal to three and the degrees of freedom changed as shown in Table 8. The F tests for significance in the main effects and their interactions were made according to the expected mean squares.

Bartlett's (1937) test of homogeneity of variance was applied to the error (b) mean squares of the six environments as outlined by Snedecor (1956, pages 285-289). This test indicated that these variances are not homogeneous; consequently, in a combined analysis over environments, the test of significance will not be at the exact probabilities given. Precaution in the interpretations of the F tests will be needed.

The testcrosses were of three check lines and 20 inbred lines consisting of two groups; consequently, some group and within-group comparisons are valid. The degrees of freedom and sums of squares for the entries, and interactions involving entries, in the analysis of individual and combined experiments were subdivided for orthogonal comparisons. Plant densities were in equally spaced increments, thus linear and quadratic components were obtained in all interactions involving plant densities. The degrees of freedom for the orthogonal comparisons in one environment are presented in Table 9.

Table 7. Source of variations, degrees of freedom, and expected mean squares for the combined analysis of variance for all characters except silking dates, shedding dates, and their difference

Source of variations		Degrees of freedom	Expected mean squares
Environments	(e)	5	$\sigma^2 + t\sigma_a^2 + rdt\sigma_e^2$
Reps/environments		24	
Densities	(d)	2	$\sigma^2 + t\sigma_a^2 + rt\sigma_{de}^2 + ret\kappa_d^2$
Environments x densities		10	$\sigma^2 + t\sigma_a^2 + rt\sigma_{de}^2$
Error (a)		48	$\sigma^2 + t\sigma_a^2$
Entries	(t)	22	$\sigma^2 + rd\sigma_{et}^2 + erd\kappa_t^2$
Densities x entries		44	$\sigma^2 + r\sigma_{edt}^2 + er\kappa_{td}^2$
Environments x entries		110	$\sigma^2 + rd\sigma_{et}^2$
Environments x densities x entries		220	$\sigma^2 + r\sigma_{edt}^2$
Error (b)		1584	σ^2

(where r stands for replications)

Table 8. Source of variations and the degrees of freedom for silking dates, shedding dates, and their intervals

Source of variations		Degrees of freedom
Environments	(e)	2
Reps/environments		12
Densities	(d)	2
Environments x densities		4
Error (a)		24
Entries	(t)	22
Densities x entries		44
Environments x entries		44
Environments x densities x entries		88
Error (b)		792
Total		1034

Table 9. Source of variations and degrees of freedom for the orthogonal comparisons at each environment

Source of variations	Degrees of freedom			
Replication	4			
Densities	2			
Reps x densities {error (a)}	8			
Entries	22			
Selections vs checks		1		
Among selections		19		
HP vs LP				1
Among HP				9
Among LP				9
Among checks		2		
(M14 and C103) vs (M14xC103)				1
M14 vs C103				1
Densities x entries	44			
Densities x (checks vs selection)		2		
Linear				1
Quadratic				1
Densities x (among selections)		38		
Densities x (HP vs LP)			2	
Linear				1
Quadratic				1
Densities x (among HP)			18	
Linear				9
Quadratic				9

Table 9 (Continued)

Source of variations	Degrees of freedom			
Densities x (among LP)			18	
Linear				9
Quadratic				9
Densities x (among checks)		4		
Densities x {(M14 and C103) vs (M14xC103)}			2	
Linear				1
Quadratic				1
Densities x (M14 vs C103)			2	
Linear				1
Quadratic				1
Error (b)	264			
Total	344			

Another set of orthogonal comparisons based on the breeding history of the selections is possible. Since differences of reaction based on the breeding history may be revealed, these orthogonal comparisons were made. The following Table 10 shows the groups involved and the member lines in each group.

Table 10. Group description, symbol and entries involved in each group for both types of breakdown of selections under study

Group	Description	Symbol	Entries involved
Original plan		OP	
1	High performance group	HP	1-10
2	Low performance group	LP	11-20
Second plan		SP	
Testcross performance selected at			
0	Both high and low plant densities	TC.B	1,2
1	High plant density	TC.H	4,5,6,14,15
2	Low plant density	TC.L	3,11,12,13
Visual discrimination at			
3	High plant density	VS.H	9,10,18,19,20
4	Low plant density	VS.L	7,8,16,17

To study the trend of yield and all ear and plant characters across plant densities, the linear and quadratic regression coefficients were computed using orthogonal polynomial coefficients for the three plant densities as follows:

	Plant Density		
	Low	Medium	High
Linear	-1	0	+1
Quadratic	+1	-2	+1

The three plant densities are spaced in equal increments based on area per plant. The densities are assumed the independent variables, and the plant and ear characters the dependent variables.

The phenotypic and genotypic correlations between grain yield and each of the 12 characters are of interest for the entries component. To calculate these correlations an estimate of genotypic variances (κ_e^2) component for yield and each of the other characters for entries and the covariances $\kappa x_i y$ of each of the (i) characters with yield (y) were obtained from the analysis of variance and covariance combined over environments. The estimates of variance and covariance components were obtained as follows:

Source of variation	Degrees of freedom	Expected mean squares
Entries	22	$\sigma^2 + rs\sigma_{et}^2 + ers\kappa_t^2$
Entries x environments	110	$\sigma^2 + rs\sigma_{et}^2$

Thus, $\kappa_{t(y)}^2$ for yield = (Ent. m.s. - Ent. x env. m.s.)/ers. In the same way, estimates of $\kappa_{t(x_i)}^2$, where x_i is the character under study, were calculated. Similarly, using mean cross products of each character with yield, estimates of $\kappa_{t(x_i y)}$ were obtained. Therefore, the genotypic correlation coefficients between yield and x_i character were calculated as follows:

$$\gamma_{g(x_i y)} = \frac{\kappa_{t(x_i y)}}{\sqrt{\kappa^2_{t(y)} \cdot \kappa^2_{t(x_i)}}}$$

The phenotypic correlations were calculated simply by using the mean squares of yield and x_i character and the cross products between yield and x_i character divided by their degrees of freedom as in the following formula:

$$\gamma_{ph(x_i y)} = \frac{\text{Ent cross product of } x_i y/\text{Ent d.f.}}{\sqrt{\text{Ent } x_i \text{ m.s.} \cdot \text{Ent y m.s.}}}$$

<u>2. Rate of cob growth for the top two ears during the 15-day period before silk emergence</u>

The model used in analyzing the cob growth data in individual experiments was as follows:

$$Y, TY = A(I) + B(J) + AB(IJ) + C(K) + BC(JK) + \varepsilon(IJK)$$

where

Y = the original measurements

TY = the $\log_{10}$ of Y

A = replication effects, i = 1-5

B = entries effects, j = 1-22

C = dates effects, k = 1-6

AB = main plot error {error (a)}

BC = entries x dates interaction

ε = subplot error {error (b)}

The assumptions for the model are that $AB(IJ) \sim N(0, \sigma_w^2)$ and $\varepsilon(IJK) \sim N(0, \sigma_e^2)$. Entries and dates are considered fixed effects and replications as random. The sources of variation, degrees of freedom, and expected mean squares for the analysis of variance are presented in Table 11.

Table 11. Source of variations, degrees of freedom, and expected mean squares for the analysis of variance of cob growth experiments at each environment

Source of variations		Degrees of freedom	Expected mean squares
Replications	(r)	4	$\sigma^2 + d\sigma_a^2 + ed\sigma_r^2$
Entries	(e)	21	$\sigma^2 + d\sigma_a^2 + rd\kappa_e^2$
Reps x entries	{error (a)}	84	$\sigma^2 + d\sigma_a^2$
Dates	(d)	5	$\sigma^2 + re\kappa_d^2$
Entries x dates		105	$\sigma^2 + r\kappa_{ed}^2$
Error (b)		440	σ^2
Total		659	

Because the cob growth data indicated curvilinear trends, analyses were made for both the original data and data after transformation by taking the logarithms of the cob measurements. The F tests for the main effects and their interactions were made according to the expected mean squares. The degrees of freedom and sums of squares for entries and their interactions were subdivided to provide orthogonal comparisons as described in the previous section. The analysis of variance based on transformed data showed that most of the variation among dates was explained by the linear model. Consequently, the analysis for experiments combined over years was done with transformed data only. The combined analysis was with entry means rather than plot data. Entries and dates are considered fixed effects and environments as random effects. The model used is as follows:

$$TY = A(I) + B(IJ) + C(K) + AC(IK) + BC(IJK) + AD(IL) + CD(KL) + ACD(IKL) + \varepsilon(IJKL)$$

where

A = environments effect, i = 1-2

B = reps/environment, j = 1-5

C = entries effect, k = 1-22

D = dates effect, l = 1-6

BC = the whole-plot error {error (a)}

ε = the subplot error {error (b)}

The assumptions for the model are $BC(IJK) \sim N(0, \sigma_w^2)$ and $\varepsilon(IJKL) \sim N(0, \sigma_e^2)$. The source of variations, degrees of freedom, and expected mean squares for the analysis of variance are presented in Table 12.

The F test for significance of the main effects and their interactions were made according to the expected mean squares. The degrees of freedom and sums of squares of the main effects and their interactions were subdivided to obtain the orthogonal components as described earlier.

Table 12. Source of variations, degrees of freedom, and expected mean squares for the combined analysis of variance over years for cob growth experiments

Source of variations		Degrees of freedom	Expected mean squares
Environments	(e)	1	$\sigma^2 + d\sigma_a^2 + rdt\sigma_e^2$
Reps/environments		8	
Entries	(t)	21	$\sigma^2 + d\sigma_a^2 + rd\sigma_{et}^2 + red\kappa_t^2$
Environments x entries		21	$\sigma^2 + d\sigma_a^2 + rd\sigma_{et}^2$
Error (a)		168	$\sigma^2 + d\sigma_a^2$
Dates	(d)	5	$\sigma^2 + re\sigma_{td}^2 + ret\kappa_d^2$
Environments x dates		5	$\sigma^2 + rt\sigma_{ed}^2$
Entries x dates		105	$\sigma^2 + r\sigma_{etd}^2 + er\kappa_{td}^2$
Environments x entries x dates		105	$\sigma^2 + r\sigma_{etd}^2$
Error (b)		880	σ^2
Total		1319	

In addition to the statistical treatment of the data for entries and dates, the cob measurements for the final date were analyzed separately. Orthogonal comparisons as described previously were obtained.

The linear regression coefficients for each entry over the six dates were calculated for the top and the second cobs. The ratio between the final lengths of the second and top cobs were also calculated for each entry.

The phenotypic correlations were calculated between pairs of L_1, b_1, L_2, b_2, L_2/L_1, b_r, and $\bar{x}$ where

L_1 = final length of the top cob

b_1 = linear regression coefficient of top cob length over dates

L_2 = final length of the second cob

b_2 = linear regression coefficient of the second cob length over dates

L_2/L_1 = the ratio of the final length of second cob and top cob

b_r = linear regression coefficient of the yield of the testcross of each entry over the three plant densities combined over six environments

$\bar{x}$ = the average mean yield of each testcross over rates and environments.

The calculations of the phenotypic correlation coefficients were done taking in account only the 20 entries; the checks were not included. Thus, there are 18 degrees of freedom for testing the significance of the r values.

3. Effectiveness of visual and testcross selection to improve combining ability of inbred lines in three successive generations

Data taken for yield and moisture at harvest were analyzed according to the standard procedure for the split-plot design. The model used for individual experiment is as follows:

$$Y_1, Y_2 = A(I) + B(J) + AB(IJ) + C(K) + BC(JK) + \varepsilon(IJK)$$

where

Y_1 = yield adjusted for moisture

Y_2 = moisture at harvest

A = replications effect, i = 1-3

B = families effect, j = 1-20

C = generations effect, k = 1-4

AB = main plot error {error (a)}

ε = subplot error {error (b)}

The assumptions for the model are that $AB(IJ) \sim N(0, \sigma_w^2)$ and $\varepsilon(IJK) \sim N(0, \sigma_e^2)$. The source of variations, degrees of freedom, and expected mean squares for the analysis of variance are presented in Table 13. The calculations of the expected mean squares were made considering families and generations as fixed effects and replications as random effects.

Table 13. Source of variations, degrees of freedom, and expected mean squares for the analysis of variance of the individual environment of the combining ability experiments

Source of variations		Degrees of freedom	Expected mean squares
Replications	(r)	2	$\sigma^2 + g\sigma_a^2 + fg\sigma_r^2$
Families	(f)	19	$\sigma^2 + g\sigma_a^2 + rg\kappa_f^2$
Reps x families {error (a)}		38	$\sigma^2 + g\sigma_a^2$
Generations	(g)	3	$\sigma^2 + rf\kappa_g^2$
Families x generations		57	$\sigma^2 + r\kappa_{gf}^2$
Error (b)		120	σ^2
Total		239	

The F test for the main effects and interactions were made according to the expected mean squares.

The combined analysis was done on the basis of the entry means; consequently, replications within environments sums of squares were estimated by pooling sums of squares from each individual environment and dividing by number of replications. Families and generations are considered fixed effects, but environments are considered random. The model used is as follows:

$$Y_1, Y_2 = A(I) + B(IJ) + C(K) + AC(IK) + BC(IJK) + D(L) + AD(IL) + CD(KL) + ACD(IKL) + \varepsilon(IJKL)$$

where

A = environments effects, $i = 1-8$

B = reps/environments, $j = 1-3$

C = families effects, $k = 1-20$

D = generations effects, $l = 1-4$

BC = the main plot error {error (a)}

ε = the subplot error {error (b)}

The assumptions for the model are $BC(IJK) \sim N(0, \sigma_w^2)$ and $\varepsilon(IJKL) \sim N(0, \sigma_e^2)$. The source of variations, degrees of freedom, and expected mean squares for the analysis of variance are presented in Table 14.

The F tests for significance of the main effects and their interactions were made according to the expected mean squares. Due to heterogeneity of error (b) mean squares over the eight environments, the tests of significance in the combined analysis will not be at the exact probability given. Precaution in the interpretations of the F test will be needed.

Table 14. Source of variations, degrees of freedom, and expected mean squares for the combined over eight environments for the combining ability experiments

Source of variations		Degrees of freedom	Expected mean squares
Environments	(e)	7	$\sigma^2 + g\sigma_a^2 + rgf\sigma_e^2$
Reps/environments		16	
Families	(f)	19	$\sigma^2 + g\sigma_a^2 + rg\sigma_{ef}^2 + reg\kappa_f^2$
Environments x families		133	$\sigma^2 + g\sigma_a^2 + rg\sigma_{ef}^2$
Error (a)		304	$\sigma^2 + g\sigma_a^2$
Generations	(g)	3	$\sigma^2 + rf\sigma_{eg}^2 + erf\kappa_g^2$
Environments x generations		21	$\sigma^2 + rf\sigma_{eg}^2$
Families x generations		57	$\sigma^2 + r\sigma_{efg}^2 + re\kappa_{fg}^2$
Env x families x generations		399	$\sigma^2 + r\sigma_{efg}^2$
Error (b)		960	σ^2
Total		1919	

To study the trend of yield and moisture across generations the assumptions were made that generations are equally spaced and independent variables and yield and grain moisture are the dependent variables. The linear, quadratic, and cubic regression coefficients were computed using the orthogonal polynomial coefficients for the four generations in Table 15.

Table 15. Orthogonal polynomial coefficients for four generations

Coefficients	Generations			
	Check	F_2	F_3	F_4
Linear	-3	-1	+1	+3
Quadratic	+1	-1	-1	+1
Cubic	-1	+3	-3	+1

The basis of selection for the lines tested, as described for Materials, permit comparisons among and within groups. Consequently, the degrees of freedom and sums of squares were subdivided to give orthogonal comparisons as shown in Table 16.

Table 16. Source of variations and degrees of freedom for the orthogonal comparisons at individual environments of the combining ability experiments

Source of variations	Degrees of freedom		
Replications	2		
Families	19		
(1 and 2) vs (3 and 4)			1
1 vs 2			1
3 vs 4			1
Among 1			4
Among 2			4
Among 3			4
Among 4			4
Error (a)	38		
Generations	3		
Linear			1
Quadratic			1
Cubic			1
Families x generations	57		
{(1&2) vs (3&4)} x generations		3	
Linear			1

Table 16 (Continued)

Source of variations	Degrees of freedom	
Quadratic		1
Cubic		1
(1 vs 2) x generations	3	
Linear		1
Quadratic		1
Cubic		1
(3 vs 4) x generations	3	
Linear		1
Quadratic		1
Cubic		1
Among 1 x generations	12	
Linear		4
Quadratic		4
Cubic		4
Among 2 x generations	12	
Linear		4
Quadratic		4
Cubic		4
Among 3 x generations	12	
Linear		4
Quadratic		4
Cubic		4
Among 4 x generations	12	
Linear		4
Quadratic		4
Cubic		4
Error (b)	120	
Total	239	

The 20 families may be separated into four groups on the basis of their breeding history. The designations of these groups and the number of lines in each are shown in Table 17. With this grouping as the basis, orthogonal comparisons for the families and interactions involving families were obtained.

F tests for the orthogonal components of families in the combined analysis were calculated using the environments by family interaction

Table 17. Group description, symbol and number of families involved in each group for both types of breakdown of selections under study for combining ability experiments

Group	Description		No. families
Original plan		OP	
1	Visual selection and high testcross performance	VS.HP	5
2	Visual selection and low testcross performance	VS.LP	5
3	Testcross selection and high testcross performance	TC.HP	5
4	Testcross selection and low testcross performance	TC.LP	5
Second plan		SP	
1	Visual selection at high plant density	VS.HS	4
2	Visual selection at low plant density	VS.LS	6
3	Testcross selection at high plant density	TC.HS	4
4	Testcross selection at low plant density	TC.LS	6

mean squares as the denominator. Also, for the orthogonal comparisons in families x generations the denominator in the F tests was environments x families x generations. The partitioned mean squares in these error terms were not used in the F tests because with so few degrees of freedom the estimates may have considerable error.

In addition to the statistical treatment of the data, the linear and quadratic regression coefficients for each family across generations were calculated for yield and moisture combined over eight environments. Linear and quadratic regression coefficients were also calculated for the group means across generations.

IV. EXPERIMENTAL RESULTS

The data will be presented in two separate parts. Part a) is the evaluation of testcrosses of 20 inbred lines and three checks for the relationship between grain yield and plant and ear characters, and effects of plant stand densities on this relationship. This part includes a study on the rate of cob growth during the 15-day period before silk emergence for the two top ears of the inbred lines and the relationship of cob development to yield of the testcrosses. Part b) is a study on the effectiveness of selection in three successive generations in segregating material to improve combining ability in 20 inbred lines.

A. Part a)

This research included two groups of inbred lines, ten lines in each, that had distinct differences in testcross performance in the study of Russell and Teich (1967) presented in Table 1 of the Materials and Methods. The first group included lines whose testcrosses had high, positive linear regression for behavior with stand densities and/or high mean yields, defined as a high performance group (HP). The second group included lines whose testcrosses had high, negative linear regression and lower mean yield than the first group, defined as a low performance group (LP). These two distinct groups were chosen to permit evaluations of relative effects of plant and ear characters in the yield potential of these materials.

The mean yields over all testcrosses of selections and checks at three plant densities at each of six environments are presented in Table 18. Although all yield data were obtained on a per-plant basis, they were converted to quintals per hectare because it is more common to use yield per area rather than yield per plant. Means over all densities for each environment and means of each density over all environments are

Table 18. Grain yield for three population densities at six environments

Environment		Yield in q/ha			
Location	Year	Low[a]	Medium	High	Mean
Ames	1966	74.7	82.0	90.0	82.2
Kanawha	1967	60.4	72.2	73.8	68.8
Ames	1967	65.7	74.5	69.7	69.9
Kanawha	1968	64.8	73.4	81.7	73.3
Ames	1968	67.9	76.7	83.5	76.0
Ankeny	1968	57.7	58.3	56.0	57.3
Mean		65.2	73.8	75.7	71.2

[a]Plant densities.

included. Ames, 1966, had the highest yield of all environments at all stand densities while Ankeny, 1968, averaged the lowest yield at all densities. The difference between the high and low yield environments over all densities was considerably greater than the difference between the high and low yield densities over all environments. Differences between the high and low yield environments were greatest at the high density and least at the low density; however, the variation in relative yields at the three densities among the environments was not great enough to give a significant interaction (Table 21). Only two environments, Ames in 1967 and Ankeny in 1968, showed a decrease in yield at the high density. The coefficient of variability (c.v. %) ranged from 7.6 to 14.4 for yield of the six environments, Tables 51-56 of the Appendix.

Mean yields of the testcrosses of the 20 selections and the three checks at the three plant densities, combined over six environments, are presented in Table 19. Linear and quadratic regression values are included. The analysis of variance for the combined yield data, with

Table 19. Average yield for 20 selected lines and three checks in test-cross performance, data summarized for three population levels over six environments

Entry no.[a]	Yield in q/ha Low[b]	Medium	High	Mean	Regression coefficients R_ℓ	R_q
HP group						
01	65.8	77.2	79.9	74.3	7.05	-1.45
02	63.3	73.6	81.3	72.7	9.00	-0.30
03	66.7	75.8	80.0	74.2	6.65	-0.82
04	67.8	76.7	79.3	74.6	5.75	-1.05
05	65.2	69.7	73.8	69.6	4.30	-0.07
06	67.5	74.1	79.7	73.8	6.10	-0.17
07	68.6	76.0	85.7	76.8	8.55	-0.38
08	66.1	74.5	76.6	72.4	5.25	-1.05
09	63.8	70.5	74.8	69.7	5.50	-0.40
10	67.2	77.5	91.0	78.6	11.90	-0.53
$\bar{x}$	66.2	74.6	80.2	73.7	7.00	-0.47
LP group						
11	64.8	72.9	74.5	70.7	4.85	-1.08
12	66.1	75.1	71.2	70.8	2.55	-2.15
13	64.4	69.6	72.6	68.9	4.10	-0.37
14	66.0	76.5	81.4	74.6	7.70	-0.93
15	62.7	69.5	71.8	68.0	4.55	-0.75
16	61.8	66.7	57.2	61.9	-2.30	-2.40
17	64.7	71.4	72.4	69.5	3.85	-0.95
18	66.0	74.8	73.5	71.5	3.75	-1.68
19	69.9	74.8	76.0	73.6	3.05	-0.62
20	64.4	72.7	73.6	70.2	4.60	-1.23
$\bar{x}$	65.1	72.4	72.4	70.0	3.65	-1.22
Checks						
21	65.1	72.8	73.9	70.6	4.45	-1.12
22	57.1	66.9	68.9	64.3	5.90	-1.30
23	64.5	68.1	71.7	68.1	3.60	0.00

[a]See Table 1 for pedigrees of entry numbers.

[b]Plant densities.

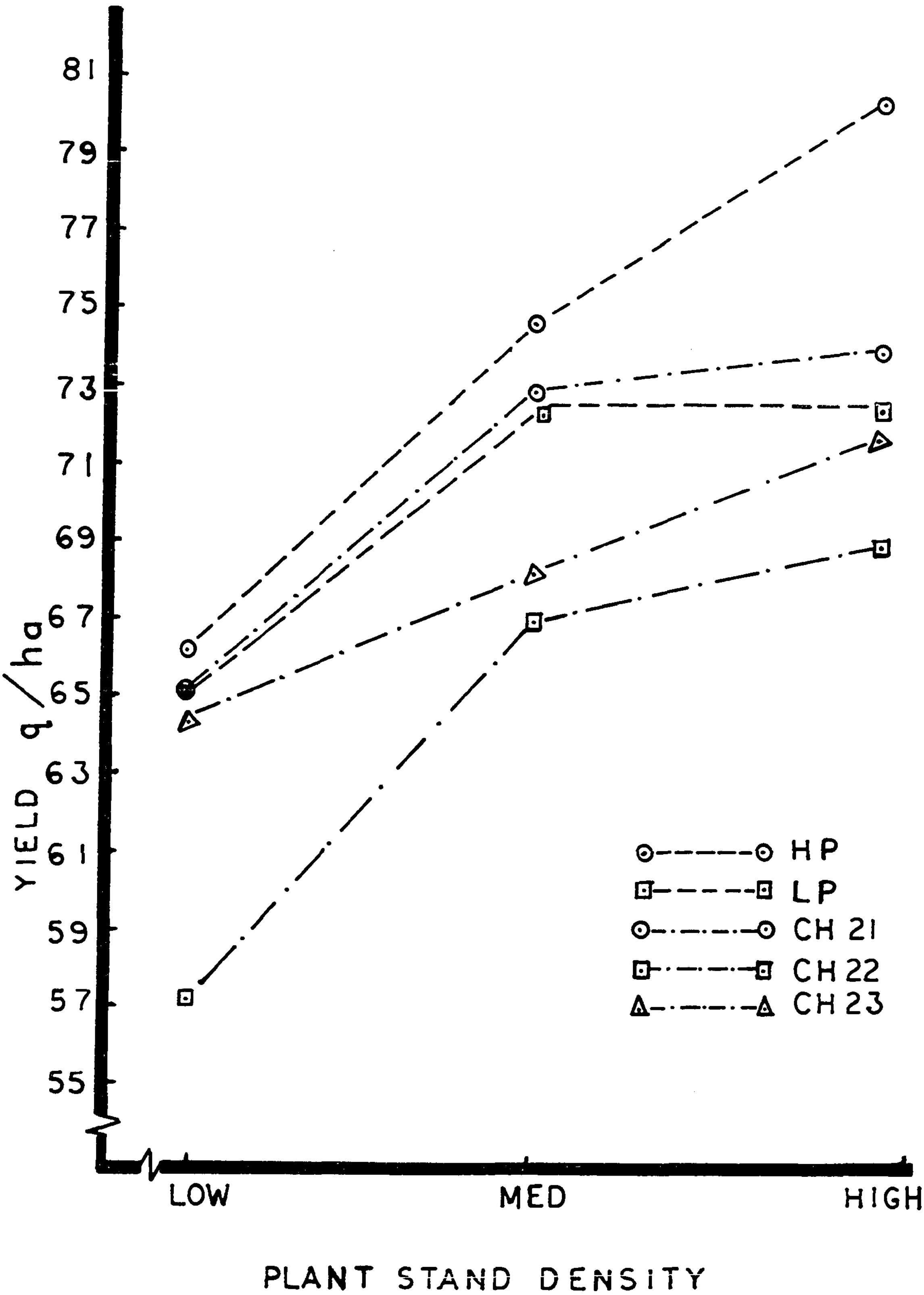
appropriate orthogonal comparisons among and within groups and linear and quadratic components of plant densities, is given in Table 21. Yield data for the individual environments and the analyses of variance for each experiment are given in Tables 45-50 and 51-56 of the Appendix, respectively.

The mean yield of the testcrosses of the selected lines was greater than the mean for the checks ($p < 0.01$). Testcrosses of the HP group yielded 3.7 q/ha higher than testcrosses of the LP group, the difference being highly significant. Yields of the two groups differed by 1.1 q/ha at the low density, 2.2 q/ha at the intermediate density, and 7.8 q/ha at the high density. Differences among testcrosses were significant in the HP group and highly significant in the LP group. The relative yields for the two groups were similar to the results of Russell and Teich (1967), Table 1, and the testcrosses for entries 10 and 16 had the highest and lowest yields, respectively, in the two studies.

The interaction of densities x entries was highly significant because of variations among the testcrosses in relative performance in the three plant densities. Most important of the orthogonal comparisons was the densities-linear x (HP group vs LP group). This comparison indicated a highly significant difference in the linear regression values for the two groups, $b = 7.00$ for the HP group, and $b = 3.65$ for the LP group. The HP group had a yield increase of 14.0 q/ha from the lowest to the highest density, but the LP group had a yield increase of only 7.3 q/ha. The LP group had an increase of 7.3 q/ha from the low to the intermediate density, but no further increase to the high density. Relative performances of the two groups and three checks at the three densities combined over six environments are shown best in Figure 1. Differences among individual testcrosses for response to stand densities were significant in the HP group and highly significant in the LP group. All testcrosses in the HP group had an increased yield at the high density as compared to the intermediate density, but only seven testcrosses in the LP group had highest yields at the high density. In the present study only entry 16 had a negative, linear regression, whereas in the Russell and Teich (1967) study all testcrosses in the LP group had negative, linear regressions (Table 1). This difference of response to stand densities in the two studies probably resulted because of environmental effects that caused higher yields in the present study. In three lower yield environments, Kanawha (1967), Ames (1967), and Ankeny (1968), (Tables 46, 47, and 50 of the Appendix), there were several more negative, linear regressions in the LP group, but still few negative values in the HP group. The highest yielding testcross in the HP group, entry 10, had the highest linear regression value, and the lowest yielding testcross in the LP group, entry 16, had the only negative regression value (Table 19).

Environments x entries interaction was highly significant, and all orthogonal comparisons in this interaction were highly significant (Table 21). Differences among environments were highly significant and, evidently, the testcrosses were affected differently by the productive potential of the environments. The interaction, environments x (HP vs LP), was highly significant because of variation in magnitude of the differences in mean yield of the two groups among the environments. There was no apparent relationship between yields levels of the

Figure 1. Mean testcross yields of high and low performance groups, C103, M14 and (C103xM14) at three plant densities, data averaged over six environments



81
79
77
75
73
71
69
67
65
63
61
59
57
55
YIELD q/ha
HP
LP
CH 21
CH 22
CH 23
LOW
MED
HIGH
PLANT STAND DENSITY

environments and magnitude of the difference between the two groups. In all environments, the HP group had the greater mean yield. An appreciable portion of the environments x entries interaction was contributed by the check-testcrosses, mainly because of a relatively poor performance of C103 at Kanawha in 1967 and 1968 (Tables 46 and 48 of the Appendix).

The second order interaction was not significant. Two of the orthogonal comparisons were significant at the 5% level, probably a sampling deviation rather than a real effect. This may be interpreted that the densities x entries interactions were consistent over environments and the environments x entries interactions were consistent over densities.

The mean values for 12 agronomic characters of the testcrosses of 20 selections and three checks at the three plant densities, combined over six environments, are presented in Tables 63-74 of the Appendix. The complete combined analyses of variance for these data are shown in Table 21. Means for the two groups and the testcross of M14xC103 are given in Table 20. Differences among mean values for all entries and all selections, combined over plant densities and environments, were highly significant for all characters (Table 21). Mean values of checks and selections differed significantly for all characters except plant and ear height. Differences among selections within groups gave greater mean squares in the HP group for six characters and in the LP group for six characters.

The interaction of densities x entries was of much greater importance in ear characters than plant characters. None of the orthogonal comparisons in plant densities x entries interactions was significant

Table 20. Group means of 12 agronomic characters for 20 selected lines and the M14xC103 check in testcross performance, data summarized for three population levels over six environments

Character	Group	Plant densities Low	Med.	High	Mean	Regression coefficients[a] R_ℓ	R_q
Plant height (cm):							
	HP	211	213	215	213	1.65	0.01
	LP	211	213	214	213	1.02	-0.24
	Ch 23	214	216	216	215	0.87	-0.37
Ear height (cm):							
	HP	93	93	96	94	1.65	0.44
	LP	93	95	96	95	1.48	0.09
	Ch 23	94	95	97	95	1.60	-0.02
No. ear/plant:							
	HP	0.99	0.98	0.96	0.98	-0.015	-0.002
	LP	0.97	0.96	0.88	0.94	-0.045	-0.012
	Ch 23	0.96	0.95	0.89	0.93	-0.035	-0.008
Ear length (mm):							
	HP	195	182	156	178	-19.7	-2.1
	LP	197	182	146	175	-25.7	-3.5
	Ch 23	192	171	143	169	-24.5	-1.1
Ear diameter (mm):							
	HP	50	48	44	47	-3.1	-0.4
	LP	48	46	40	45	-4.2	-0.8
	Ch 23	49	46	40	45	-4.2	-0.5
Shelling percent:							
	HP	82.4	82.6	82.5	82.5	0.04	-0.06
	LP	81.7	81.7	81.2	81.5	-0.25	-0.10
	Ch 23	81.7	81.9	81.7	81.8	0.01	-0.05
300-kernel wt. (g):							
	HP	85.1	79.1	71.5	78.8	-6.79	-0.28
	LP	86.0	81.0	74.4	80.5	-5.83	-0.28
	Ch 23	85.2	80.6	75.8	80.5	-4.71	-0.05
Kernel depth (mm):							
	HP	20	19	17	19	-1.4	-0.1
	LP	19	18	16	18	-1.5	-0.3
	Ch 23	19	18	16	18	-1.5	-0.3

[a]Regression coefficients were calculated using more decimal places than given for the mean values presented for this table.

Table 20 (Continued)

Character	Group	Plant densities Low	Med.	High	Mean	Regression coefficients[a] R_ℓ	R_q
No. seed/plant:							
	HP	755	692	561	669	-96.7	-11.3
	LP	731	658	490	627	-120.5	-15.9
	Ch 23	727	623	473	608	-127.2	-7.6
Silking date:							
	HP	27.5	27.6	28.9	28.0	0.70	0.18
	LP	27.9	28.2	29.7	28.6	0.93	0.20
	Ch 23	27.9	28.1	29.5	28.5	0.80	0.18
Shedding date:							
	HP	27.0	26.7	27.1	26.9	0.04	0.11
	LP	27.1	27.0	27.5	27.2	0.22	0.11
	Ch 23	27.4	27.1	27.5	27.3	0.04	0.10
(Silking date-shedding date) + 10:							
	HP	10.5	10.9	11.8	11.1	0.68	0.08
	LP	10.8	11.3	12.3	11.5	0.71	0.09
	Ch 23	10.5	11.0	12.0	11.2	0.77	0.08

for ear height and only densities x among LP group (linear component) was highly significant for plant height. With the increase in plant densities, ear height increased for all entries and plant height increased for all except three entries (Tables 63 and 64 of the Appendix). Densities x among selections was highly significant for all ear characters (Table 21). For all ear characters except shelling percent, the mean values for entries usually decreased as plant density increased. The differential effect of plant densities on ear characters was greater among selections in the LP group than in the HP group. In most cases where there was a significant interaction involving plant densities, it was caused mainly by differences for the linear component. The relative

Table 21. Analyses of variance of 13 agronomic characters for 20 selected lines and three checks in testcross performance combined over six environments

Source of variations	Degrees of freedom	Mean squares				
		Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Environments	5	24922.9**	4.77	9154.29**	2510.00**	50.80*
Replication/environments	24	1737.4	0.41	276.32	45.98	5.81
Densities	2	244357.7**	16.11*	225.19	401.47**	731.87**
Environments x densities	10	967.1	1.18	153.09	37.53	4.03
Error (a)	48	4407.4	2.71	550.06	223.95	17.68
Entries	22	1210.2**	1.55**	502.50**	312.14**	14.76**
Selections vs checks	1	4508.7**	3.25**	93.23	3.45	34.53**
Among selections[b]	19	9000.9**	1.25**	313.90**	262.48**	13.06**
HP vs LP	1	4778.6**	12.84**	12.47	23.31	4.51
Among HP	9	639.0*	0.29	550.02**	349.57**	5.68**
Among LP	9	1019.2**	1.34**	215.90**	289.47**	25.75**
Among checks	2	1206.7**	1.69**	2028.02**	544.53**	0.43
(M14&C103) vs (M14xC103)	1	74.0	0.02	32.23	19.76	0.11
M14 vs C103	1	2339.3**	3.36**	4023.79**	1069.29**	0.75
Densities x entries	44	159.3**	0.35**	23.98	6.83	1.64**
Densities x (sel vs ch)	2	38.9	0.10	4.74	6.58	0.22
Linear	1	71.9	0.02	9.22	12.92	0.41
Quadratic	1	5.9	0.17	0.25	0.23	0.02

[a]Observed values were multiplied by 10^2.

[b]Orthogonal comparisons based on reasons lines were selected for the study (Table 1).

*5% significant differences in this and all following tables.

**1% significant differences in this and all following tables.

Table 21 (Continued)

Source of variations	Degrees of freedom	Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
			Mean squares			
Densities x (among sel)	38	157.3**	0.39**	26.59	6.84	1.70**
Densities x (HP vs LP)	2	771.1**	2.74**	17.99	11.95	12.61**
Linear	1	1360.4**	4.00**	24.32	1.77	21.43**
Quadratic	1	181.8	1.48**	11.65	22.12	3.79**
Densities x (among HP)	18	119.2*	0.06	18.92	4.70	0.41
Linear	9	169.1*	0.10	24.78	4.80	0.55
Quadratic	9	69.4	0.02	13.05	4.61	0.27
Densities x (among LP)	18	127.2*	0.47**	35.22*	8.40	1.78**
Linear	9	192.8**	0.82**	53.24**	11.55	2.74**
Quadratic	9	61.7	0.11	17.20	5.26	0.83
Densities x (among checks)	4	238.6*	0.12	8.81	6.85	1.76**
Dens x{(M14&C103)vs(M14xC103)}	2	252.3*	0.05	1.18	6.25	1.42*
Linear	1	231.1	0.02	0.11	4.68	1.52
Quadratic	1	273.4	0.07	2.24	6.00	1.31
Densities x (M14 vs C103)	2	225.0	0.19	16.45	7.50	2.11*
Linear	1	438.6*	0.11	6.00	5.23	3.10*
Quadratic	1	11.4	0.27	26.89	9.68	1.12
Environments x entries	110	269.6**	0.17**	25.62*	18.37**	1.62**
Env x (sel vs checks)	5	239.0**	0.11	32.87	24.56**	6.91**
Env x (among sel)	95	188.5**	0.16*	21.50	15.89**	1.06**
Env x (HP vs LP)	5	485.7**	0.23	44.00*	27.56**	3.00**
Env x (among HP)	45	201.1**	0.07	28.39**	19.62**	0.87**
Env x (among LP)	45	217.0**	0.23**	22.58	17.34**	1.55**
Env x (among checks)	10	772.8**	0.32**	28.99	12.95	2.77**
Env x (M14&C103)vs(M14xC103)	5	324.5**	0.30*	22.36	9.60	1.11
Env x (M14 vs C103)	5	1221.2**	0.34**	35.63	16.31	4.42**
Env x densities x entries	220	76.6	0.13*	19.15	7.23	0.54
Env x densities x (sel vs ch)	10	152.5*	0.16	2.76	9.29	0.84
Linear	5	107.9	0.21	3.66	8.90	0.85
Quadratic	5	199.1*	0.11	1.86	9.72	0.83

Table 21 (Continued)

Source of variations	Degrees of freedom			Mean squares: Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Env x densities x (among sel)	190			73.9	0.13*	20.78	7.03	0.52
Env x densities x (HP vs LP)		10		90.2	0.31**	22.94	7.87	1.01*
Linear			5	62.5	0.51**	9.77	6.23	1.64**
Quadratic			5	117.9	0.11	36.10	9.51	0.39
Env x densities x (among HP)		90		61.3	0.06	16.61	8.03	0.28
Linear			45	52.0	0.07	2.95	6.32	0.29
Quadratic			45	72.5	0.05	12.27	9.74	0.28
Env x densities x (among LP)		90		84.6	0.02	24.56**	5.99	0.71**
Linear			45	78.4	0.20**	35.55**	6.33	0.76*
Quadratic			45	90.7	0.17*	13.58	5.65	0.66
Env x densities x (among checks)	20			65.0	0.13	11.92	8.06	0.61
Env x den x{(M14&C103)vs(M14xC103)}		10		58.4	0.14	6.96	11.37	0.50
Linear			5	81.6	0.20	3.75	8.60	0.54
Quadratic			5	35.3	0.09	10.17	14.13*	0.45
Env x densities x(M14 vs C103)		10		71.6	0.11	16.86	4.75	0.72
Linear			5	78.2	0.13	14.80	2.83	0.84
Quadratic			5	65.0	0.09	18.94	6.66	0.61
Error (b)	1584			70.9	0.11	17.52	7.43	0.52
Total	2069							
c.v. (%)				10.46	7.74	4.15	6.44	9.19

Source of variations	Degrees of freedom	Ear diameter[a]	Shelling percent	Kernel depth[a]	300 Kernel weight	No. seeds per plant
Environments	5	172.78	120.53**	71.01**	1338.07**	114083.6*
Replications/environments	24	22.07	1.26	4.52	130.21	10071.5
Densities	2	1966.61**	3.59	349.68**	5110.54**	1722987.0**
Environments x densities	10	28.12	2.82	4.91	36.58	15587.7
Error (a)	48	78.69	6.75	16.28	217.46	40489.6

Table 21 (Continued)

Source of variations	Degrees of freedom	Mean squares: Ear diameter[a]	Shelling percent	Kernel depth[a]	300 Kernel weight	No. seeds per plant
Entries	22	70.51**	16.63**	26.51**	415.85**	41816.7**
Selections vs checks	1	81.40**	9.60**	24.57**	95.50*	114008.2**
Among selections[b]	19	57.91**	12.50**	22.90**	384.12**	30762.7**
HP vs LP	1	507.89**	86.18**	106.71**	251.94**	163302.8**
Among HP	9	19.20**	9.05**	11.72**	546.87**	28775.5**
Among LP	9	65.93**	11.94**	32.39**	364.11**	28277.3**
Among checks	2	97.82**	40.61**	27.43**	301.21**	64590.0**
(M14&C103)vs(M14xC103)	1	2.43	0.95	1.08	7.70	2040.2
M14 vs C103	1	93.21**	80.28**	53.78**	594.71**	127139.8**
Densities x entries	44	8.25**	0.79**	1.49**	16.51**	3753.0**
Densities x (sel vs ch)	2	1.26	0.04	0.48	27.91*	336.5
Linear	1	0.81	0.01	0.00	55.06**	650.0
Quadratic	1	1.71	0.05	1.95*	0.76	23.0
Densities x (among sel)	38	9.27**	0.91**	1.64**	17.58**	3953.3**
Densities x (HP vs LP)	2	51.71**	2.43**	5.48**	20.25*	18919.4**
Linear	1	73.48**	4.56**	3.31**	39.11*	34024.5**
Quadratic	1	29.93**	0.29	7.65**	1.39	3814.3
Densities x (among HP)	18	2.00	0.61	0.68	15.33**	3406.1**
Linear	9	2.56	0.98*	0.83	21.45**	6049.5**
Quadratic	9	4.44	0.24	0.53	9.21	762.7
Densities x (among LP)	18	11.84**	1.04**	2.19**	19.53**	2837.6**
Linear	9	19.09**	1.30**	3.58**	36.41**	4576.3**
Quadratic	9	4.59	0.77	0.81	2.64	1098.9
Densities x (among checks)	4	2.05	0.06	0.25	0.72	3558.8*
Dens x{(M14&C103)vs(M14xC103)}	2	2.75	0.07	0.19	1.29	2871.8
Linear	1	2.96	0.13	0.00	0.77	3511.2
Quadratic	1	2.54	0.00	0.38	1.81	2232.4
Densities x (M14 vs C103)	2	1.35	0.05	0.31	0.15	4245.9*
Linear	1	0.48	0.10	0.08	0.12	8362.7*
Quadratic	1	2.21	0.00	0.53	0.18	129.1

Table 21 (Continued)

Source of variations	Degrees of freedom	Mean squares				
		Ear diameter[a]	Shelling percent	Kernel depth[a]	300 Kernel weight	No. seeds per plant
Environments x entries	110	5.22**	0.94**	1.70**	19.47**	3234.1**
Env x (sel vs checks)	5	5.20	0.73	1.69*	42.94**	518.3
Env x (among sel)	95	4.09**	0.75**	1.41**	15.99**	2511.4**
Env x (HP vs LP)	5	3.68	3.84**	1.47*	17.98**	736.4
Env x (among HP)	45	2.05	1.15**	1.11**	19.36**	2450.4**
Env x (among LP)	45	6.55**	0.25	2.00**	16.19**	3289.9**
Env x (among checks)	10	9.81**	1.80**	2.35**	16.83**	7690.8**
Env x{(M14&C103)vs(M14xC103)}	5	6.75*	1.34**	2.28**	8.01	2617.6*
Env x (M14 vs C103)	5	12.88**	2.25**	2.41**	25.66**	1276.0**
Env x densities x entries	220	4.45**	0.44*	0.49	6.21	1241.8**
Env x densities x (sel vs ch)	10	4.09	0.63	0.94	5.68	2276.2**
Linear	5	4.74	0.68	1.16	7.10	709.1
Quadratic	5	3.45	0.57	0.71	4.27	3843.2**
Env x densities x (among sel)	190	4.72**	0.41	0.41	6.37	1233.8**
Env x densities x (HP vs LP)	10	7.40**	0.42	1.59**	8.06	1681.2
Linear	5	10.76**	0.18	2.11**	13.58*	1352.6
Quadratic	5	4.05	0.65	1.07	2.54	2009.7
Env x densities x (among HP)	90	1.42	0.42	0.74	6.80	1008.9
Linear	45	1.44	0.26	0.79	9.00**	949.0
Quadratic	45	1.39	0.59*	0.69	4.58	1068.7
Env x densities x (among LP)	90	3.65*	0.40	1.13**	5.79	1409.1**
Linear	45	3.44	0.49	1.15**	6.18	1415.1*
Quadratic	45	3.86*	0.30	1.10**	5.41	1403.0*
Env x densities x (among ch)	20	2.07	0.72**	0.95	4.87	800.2
Env x den x{(M14&C103)vs(M14xC103)}	10	1.91	0.36	0.93	4.13	672.5
Linear	5	1.62	0.20	1.07	5.36	730.2
Quadratic	5	2.50	0.54	0.80	2.90	614.8
Env x densities x(M14 vs C103)	10	2.23	1.07**	0.96	5.61	927.8
Linear	5	2.72	1.85**	1.45*	4.79	651.7
Quadratic	5	1.75	0.29	0.46	6.44	1203.9

Table 21 (Continued)

Source of variations	Degrees of freedom			Mean squares: Ear diameter[a]	Shelling percent	Kernel depth[a]	300 Kernel weight	No. seeds per plant
Error (b)	1584			2.66	0.36	0.65	5.66	936.9
Total	2069							
c.v. (%)				7.93	1.63	10.00	6.66	10.66

Source of variations	Degrees of freedom			Silking date	Shedding date	(Silking date-shedding date)+10
Environments	2			718.49**	972.25**	19.38
Replications/environments	12			10.48	17.20**	1.83
Densities	2			52.15**	3.22	35.31**
Environments x densities	4			3.20	1.35	0.44
Error (a)	24			6.07	5.42	6.73
Entries	22			5.45**	4.16**	1.79**
Selections vs checks		1		1.85*	3.71**	0.33
Among selections		19		3.58**	3.45**	1.41**
HP vs LP			1	19.08**	3.04	6.65**
Among HP			9	5.06**	4.43**	1.20**
Among LP			9	1.56*	3.67**	1.51**
Among checks		2		19.70**	5.98**	4.00**
(M14&C103)vs(M14xC103)			1	0.09	0.13	0.00
M14 vs C103			1	39.31**	11.84**	8.00**
Densities x entries	44			0.32*	0.26	0.25
Densities x (sel vs ch)		2		0.09	0.08	0.13
Linear			1	0.01	0.16	0.08
Quadratic			1	0.17	0.00	0.16
Densities x (among sel)		38		0.35**	0.29	0.23
Densities x (HP vs LP)			2	0.78*	0.49	0.03
Linear			1	1.54**	0.97*	0.03
Quadratic			1	0.02	0.00	0.02

Table 21 (Continued)

Source of variations	Degrees of freedom	Mean squares Silking date	Shedding date	(Silking date-shedding date)+10
Densities x (among HP)	18	0.27	0.24	0.23
Linear	9	0.41*	0.29	0.31
Quadratic	9	0.14	0.19	0.15
Densities x (among LP)	18	0.37*	0.31	0.26
Linear	9	0.61**	0.42	0.33
Quadratic	9	0.13	0.21	0.28
Densities x (among checks)	4	0.16	0.14	0.44
Dens x{(M14&C103)vs(M14xC103)}	2	0.03	0.00	0.04
Linear	1	0.00	0.00	0.00
Quadratic	1	0.06	0.00	0.07
Dens x (M14 vs C103)	2	0.28	0.28	0.85*
Linear	1	0.56	0.16	1.33*
Quadratic	1	0.00	0.40	0.36
Environments x entries	44	0.75**	1.02**	0.36
Env x (sel vs checks)	2	0.38	1.41**	0.45
Env x (among sel)	38	0.81**	1.06**	0.38
Env x (HP vs LP)	2	0.66	0.12	0.48
Env x (among HP)	18	0.68**	0.87**	0.42*
Env x (among LP)	18	0.95**	1.36**	0.32
Env x (among checks)	4	0.41	0.45	0.13
Env x{(M14&C103)vs(M14xC103)}	2	0.45	0.18	0.13
Env x (M14 vs C103)	2	0.38	0.68*	0.13
Env x densities x entries	88	0.18	0.24	0.23
Env x densities x (sel vs ch)	4	0.12	0.08	0.17
Linear	2	0.13	0.06	0.24
Quadratic	2	0.12	0.11	0.11
Env x densities x (among sel)	76	0.19	0.26*	0.22
Env x densities x (HP vs LP)	4	0.26	0.44	0.23
Linear	2	0.39	0.71*	0.35
Quadratic	2	0.14	0.17	0.12

Table 21 (Continued)

Source of variations	Degrees of freedom				Mean squares		
					Silking date	Shedding date	(Silking date-shedding date)+10
Env x densities x (among HP)			36		0.23	0.19	0.21
Linear				18	0.21	0.22	0.25
Quadratic				18	0.25	0.15	0.17
Env x densities x (among LP)			36		0.19	0.31*	0.25
Linear				18	0.18	0.38**	0.39
Quadratic				18	0.19	0.24	0.11
Env x densities x (among checks)		8			0.16	0.15	0.35
Env x den x{(M14&C103)vs(M14xC103)}			4		0.28	0.25	0.60
Linear				2	0.30	0.16	0.09
Quadratic				2	0.26	0.35	1.12*
Env x densities x(M14 vs C103)			4		0.04	0.05	0.10
Linear				2	0.07	0.03	0.17
Quadratic				2	0.02	0.07	0.03
Error	792				0.27	0.20	0.26
Total	1034						
c.v. (%)					4.10	3.69	10.14

dates of pollen shed among the testcrosses were not affected significantly by plant density, but for date silked the densities x among selection interaction was highly significant. The stress effect of increasing plant density was to cause a delay in silk emergence, but the effect varied among the testcrosses. By contrast, increasing plant density had little effect on development of the male inflorescence.

Environments x entries was significant, or highly significant, for all characters and environments x selections was highly significant for all characters except plant height and (silking date-shedding date) difference. The differential effect of environments on the testcross means was similar among selections in the two groups. Environments x among checks was highly significant for all ear characters, caused in most cases by highly significant variations among environments for the comparison of M14vsC103 testcrosses.

The second order interaction, environments x densities x selections, was significant, or highly significant, for number of ears per plant, ear diameter, and number of seeds per plant. In addition, there were a few significant, or highly significant, orthogonal comparisons, indicating examples where the differential effects of densities were not consistent among environments and the differential effects of environments were not consistent at the three densities.

Comparisons of group means and the testcross of M14xC103 can be made for the data in Table 20. Differences between the HP and LP groups were highly significant for all characters except plant and ear heights, ear length, and date pollen shed. The differential effect of plant densities on the group means was not significant for plant and ear heights, but was significant, or highly significant, for all ear characters. The mean values for the HP group were greater than for the LP group for all ear characters except 300-kernel weight where the LP group had the greater values. In all ear characters, the densities-linear x (HP vs LP) comparison was highly significant indicating that the change in mean value (R_ℓ in Table 20) from the low to the high density was not the same for the two groups. Data in Table 20 show that for all ear characters except 300-kernel weight the decrease in mean values was greater for LP group than for HP group. The linear component of densities x (HP vs LP) was significant for shedding date and highly significant for silking date. For both characters the number of days delay from the low to the high density was greater for the LP group than the HP group.

The environmental effect on magnitude of the differences between means of HP group and LP group varied significantly, or highly significantly, for all characters except ears per plant, ear diameter, seeds per plant, and dates of silk emergence and pollen shedding. For yield, environments x (HP vs LP) was highly significant, but only four of seven ear characters had significance for this interaction. Second order interactions were significant for ear length and highly significant for ears per plant, ear diameter, and kernel depth.

As outlined in Materials and Methods, Table 10, the 20 selections belong to five groups based upon the breeding methods used in developing the lines (Russell and Teich, 1967). Mean yields for these groups and the testcross of M14xC103 are given in Table 22 and the part of the combined analyses of variance for all characters relative to testcrosses of

Table 22. Average yield for five groups of selections and the M14xC103 check in testcross performance, data summarized for three population levels over six environments

Breeding group[b]	Yield in q/ha				Regression coefficient[a]	
	Low[c]	Medium	High	Mean	R_{ℓ}	R_q
0 (TC.B)	64.6	75.4	80.7	73.5	8.03	-0.88
1 (TC.H)	65.8	73.3	77.2	72.1	5.68	-0.59
2 (TC.L)	65.5	73.4	74.6	71.2	4.54	-1.11
3 (VS.H)	66.3	74.1	77.8	72.7	5.76	-0.89
4 (VS.L)	65.3	72.2	75.5	70.2	5.10	-1.20
Check 23	64.5	68.1	71.7	68.1	3.60	0.00

[a]Regression coefficients were calculated using more decimal places for the means than presented here.

[b]Entries represented in each group are as follows:
group 0, entries 01 and 02
group 1, entries 04, 05, 06, 14, and 15
group 2, entries 03, 11, 12, and 13
group 3, entries 09, 10, 18, 19, and 20
group 4, entries 07, 08, 16, and 17.

[c]Plant densities.

the selections is given in Table 23. Analyses of variance for characters in individual environments are in Tables 57-62 of the Appendix. Figure 2 shows the plots for the five groups and the testcross of M14xC103 at the three densities.

The differences among group mean yields were not significant. In the orthogonal comparisons for groups, the greatest difference was between groups 3 and 4, and this was significant at the five percent level. Differences among testcrosses within groups were greatest in group 4, mainly because of the low value for entry 16. Lines in group 4 were selected on the basis of phenotype appearance at a low stand level. The

Table 23. Part of the analyses of variance of 13 agronomic characters for 20 selected lines and three checks in testcross performance combined over six environments

Source of variations	Degrees of freedom		Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
			Mean squares				
Among selections[b]	19		9000.0**	1.25**	313.90**	262.48**	13.06**
Group 0 vs (1&2&3&4)	1		305.2	2.61**	4.63	277.14**	11.59**
(1&2) vs (3&4)	1		2.0	0.01	0.06	35.34	65.56**
1 vs 2	1		124.8	0.17	516.48**	582.17**	7.58
3 vs 4	1		1114.9*	1.06*	434.13**	159.02**	1.79
Among 0	1		208.3	0.28	17.92	61.36	0.69
Among 1	4		891.8*	0.51*	203.23**	365.59**	24.50**
Among 2	3		417.6	0.40	11.00	15.39	9.82**
Among 3	4		1005.0**	0.90**	1086.22**	502.60**	10.87**
Among 4	3		3035.5**	5.48**	247.26**	346.88**	9.74**
Densities x among selection	38		157.3**	0.39**	26.59	6.84	1.70**
Densities x {0 vs (1&2&3&4)}	2		417.5**	0.26	59.00*	14.50	3.60**
Linear		1	760.7**	0.38	82.60*	12.79	7.19**
Quadratic		1	74.2	0.14	35.32	16.18	0.00
Densities x {(1&2) vs (3&4)}	2		9.4	0.05	11.52	3.85	0.75
Linear		1	18.3	0.09	18.38	3.89	1.37
Quadratic		1	0.5	0.01	4.67	3.71	0.13
Densities x (1 vs 2)	2		74.8	0.05	26.69	4.02	0.97
Linear		1	75.6	0.08	23.69	1.96	1.92
Quadratic		1	73.9	0.02	29.69	6.09	0.01
Densities x (3 vs 4)	2		84.6	0.68**	18.72	0.88	2.50*
Linear		1	162.4	1.20**	14.02	0.36	3.56**
Quadratic		1	6.8	0.15	23.42	1.42	1.44

[a]Observed values were multiplied by 10^2.

[b]Orthogonal comparisons based on breeding groups.

Table 23 (Continued)

Source of variations	Degrees of freedom		Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x among 0	2		114.6	0.02	33.18	4.49	0.32
Linear		1	155.0	0.00	64.68	1.50	0.21
Quadratic		1	74.0	0.03	1.68	7.48	0.43
Densities x among 1	8		54.0	0.04	32.56	8.56	0.23
Linear		4	47.2	0.03	58.60*	14.04	0.20
Quadratic		4	61.3	0.05	6.52	3.11	0.32
Densities x among 2	6		93.1	0.20	48.10	1.42	0.84
Linear		3	85.8	0.30	67.02*	1.23	1.06
Quadratic		3	97.0	0.10	29.13	1.61	0.71
Densities x among 3	8		275.5**	0.02	15.80	8.61	1.57
Linear		4	478.5**	0.31	19.35	9.22	1.90**
Quadratic		4	72.6	0.08	12.22	8.00	0.74
Densities x among 4	6		230.1**	1.63**	6.17	10.00	5.10**
Linear		3	385.5**	2.74**	3.41	10.56	8.41**
Quadratic		3	101.8	0.51**	8.93	9.00	1.78*
Env x among selections	95		188.5**	0.16*	21.50	15.89**	1.06**
Env x {group 0 vs (1&2&3&4)}		5	302.2**	0.14	44.77*	12.45	1.23*
Env x {(1&2) vs (3&4)}		5	117.7	0.15	11.91	8.79	1.23*
Env x (1 vs 2)		5	137.4	0.13	20.68	20.00*	0.65
Env x (3 vs 4)		5	478.7**	0.16	38.71*	9.81	2.37**
Env x among 0		5	52.0	0.06	28.06	2.79	1.17*
Env x among 1		20	261.8**	0.13	20.44	33.28**	0.93*
Env x among 2		15	121.2*	0.11	15.68	6.93	0.48
Env x among 3		20	207.6**	0.06	40.73**	23.83**	0.88*
Env x among 4		15	272.7**	0.43**	12.35	15.57*	2.63**
Env x densities x among selection	190		73.9	0.13*	20.78	7.03	0.52
Env x densities x {0 vs (1&2&3&4)}	10		89.2	0.14	49.64**	9.59	0.56
Linear		5	30.6	0.21	68.56**	8.00	0.89

Table 23 (Continued)

Source of variations	Degrees of freedom	Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Quadratic	5	147.7	0.06	30.72	11.30	0.23
Env x densities x {(1&2) vs (3&4)}	10	22.2	0.21	22.12	3.89	0.66
Linear	5	21.8	0.31*	25.90	4.80	1.08
Quadratic	5	22.6	0.10	18.38	2.98	0.23
Env x densities x (1 vs 2)	10	42.5	0.10	16.20	9.89	0.34
Linear	5	40.9	0.11	23.60	10.22	0.30
Quadratic	5	44.1	0.09	8.80	9.57	0.41
Env x densities x (3 vs 4)	10	45.6	0.16	11.38	6.17	0.60
Linear	5	22.0	0.12	6.71	4.04	0.50
Quadratic	5	69.1	0.20	16.06	8.30	0.73
Env x densities x among 0	10	30.2	0.05	17.98	4.83	0.10
Linear	5	48.1	0.07	20.00	6.72	0.09
Quadratic	5	12.4	0.03	16.11	2.94	0.10
Env x densities x among 1	40	99.1*	0.12	13.45	9.01	0.51
Linear	20	103.4	0.17	12.42	5.40	0.70
Quadratic	20	95.3	0.07	14.50	12.62*	0.32
Env x densities x among 2	30	92.8	0.10	45.01**	5.58	0.63
Linear	15	58.7	0.10	73.59**	7.06	0.50
Quadratic	15	133.9*	0.10	16.43	4.09	0.76
Env x densities x among 3	40	54.3	0.07	11.82	6.96	0.30
Linear	20	64.2	0.09	16.09	6.34	0.25
Quadratic	20	44.5	0.06	12.56	7.58	0.29
Env x densities x among 4	30	93.7	0.26**	10.46	6.22	0.90*
Linear	15	92.7	0.28**	10.79	6.03	0.99*
Quadratic	15	104.1	0.26**	10.11	6.41	0.78

Table 23 (Continued)

Source of variations	Degrees of freedom		Mean squares				
			Ear diameter[a]	Shelling percent	Kernel depth[a]	300 Kernel weight	No. seeds per plant
Among selections[b]	19		57.91**	12.50**	22.90**	384.12**	30762.7**
Group 0 vs (1&2&3&4)		1	225.10**	5.06*	59.10**	1200.88**	38298.2**
(1&2) vs (3&4)		1	96.48**	2.62	25.56**	530.48**	39751.5**
1 vs 2		1	0.34	18.02**	0.72	352.16**	33231.4**
3 vs 4		1	58.40**	2.67	50.93**	1061.43**	16438.5**
Among 0		1	9.40	1.95	0.03	14.26	276.7
Among 1		4	11.34	6.26**	9.85**	369.85**	17027.2**
Among 2		3	30.86**	36.92**	31.82**	481.86**	36412.5**
Among 3		4	52.68**	4.60**	22.64**	418.00**	16806.1**
Among 4		3	59.25**	30.18**	47.33**	231.65**	101400.8**
Densities x among selection	38		9.27*	0.91**	1.64**	17.58**	3953.3**
Densities x {0 vs (1&2&3&4)}		2	7.61	2.91**	1.61*	1.86	6919.3**
Linear		1	13.38	5.73**	2.66*	0.43	13823.9**
Quadratic		1	1.83	0.07	0.56	3.29	14.7
Densities x {(1&2) vs (3&4)}		2	3.28	0.21	1.31	33.57**	2102.3
Linear		1	4.45	0.00	0.07	66.76**	3688.6
Quadratic		1	2.11	0.41	2.54*	0.37	515.9
Densities x (1 vs 2)		2	1.19	0.15	0.01	21.47*	2615.0
Linear		1	2.12	0.18	0.01	42.88**	4513.6
Quadratic		1	0.25	0.12	0.00	0.07	716.0
Densities x (3 vs 4)		2	10.15	1.52*	3.65**	4.34	5081.4*
Linear		1	19.38*	0.72	7.26**	4.33	10102.8**
Quadratic		1	0.92	2.31*	0.03	4.35	60.1
Densities x among 0		2	1.58	1.31*	0.91	7.98	594.3
Linear		1	1.22	2.26*	0.43	3.00	1048.1
Quadratic		1	1.93	0.36	1.39	12.97	140.6
Densities x among 1		8	1.86	0.27	0.62	13.72*	2268.4
Linear		4	1.32	0.16	0.73	13.65	3345.6*
Quadratic		4	2.39	0.33	0.52	13.80	1191.4

Table 23 (Continued)

Source of variations	Degrees of freedom		Mean squares				
			Ear diameter[a]	Shelling percent	Kernel depth[a]	300 Kernel weight	No. seeds per plant
Densities x among 2	6		2.71	0.18	0.83	12.06	2435.0
Linear		3	3.31	0.30	0.32	31.48**	3031.1
Quadratic		3	2.11	0.06	1.33*	5.97	1838.7
Densities x among 3	8		4.72	0.80	0.72	28.20**	6319.7**
Linear		4	5. 31	1.06*	0.92	53.37**	11631.2**
Quadratic		4	4.11	0.49	0.57	2.96	1008.2
Densities x among 4	6		39.26**	2.20**	5.33**	12.00	5380.9**
Linear		3	63.79**	3.46**	8.40**	26.63**	9159.6**
Quadratic		3	14.80*	0.90	2.26**	0.70	1602.2
Env x among selections	95		4.09**	0.75**	1.41**	15.99**	2511.4**
Env x {group 0 vs (1&2&3&4)}		5	4.24	1.46**	1.21	44.44**	5379.6**
Env x {(1&2) vs (3&4)}		5	4.16	0.07	1.58*	18.27**	2133.9*
Env x (1 vs 2)		5	4.49	1.36**	2.00**	20.28**	1434.0
Env x (3 vs 4)		5	4.92	2.00**	2.27**	12.78*	3861.6**
Env x among 0		5	0.98	0.25	0.84	22.91**	2288.7*
Env x among 1		20	4.51*	0.92**	1.52**	18.71**	2184.8**
Env x among 2		15	2.50	0.54	1.04	15.09**	1789.8*
Env x among 3		20	2.49	0.97**	1.01	15.75**	3590.3**
Env x among 4		15	11.93**	0.71*	3.34**	16.65**	3994.5**
Env x densities x among selection	190		4.72**	0.41	0.41	6.37	1233.8**
Env x densities x {0 vs (1&2&3&4)}	10		2.79	0.53	0.45	7.35	604.3
Linear		5	3.12	0.19	0.71	7.29	354.6
Quadratic		5	2.46	0.86*	0.20	7.41	854.0
Env x densities x {(1&2) vs (3&4)}	10		3.11	0.40	1.39*	4.16	651.7
Linear		5	4.97	0.30	2.08**	5.11	739.5
Quadratic		5	1.26	0.50	0.69	3.22	563.9

Table 23 (Continued)

Source of variations	Degrees of freedom	Mean squares: Ear diameter[a]	Shelling percent	Kernel depth[a]	300 Kernel weight	No. seeds per plant
Env x densities x (1 vs 2)	10	2.05	0.36	0.96	6.11	958.5
Linear	5	3.29	0.51	1.53*	5.13	650.4
Quadratic	5	0.81	0.20	0.39	7.09	1266.6
Env x densities x (3 vs 4)	10	2.50	0.46	0.99	7.30	2118.2*
Linear	5	0.69	0.85*	1.36	8.80	1038.3
Quadratic	5	4.29	0.07	0.62	5.80	3198.1**
Env x densities x among 0	10	0.61	0.20	0.25	7.82	331.2
Linear	5	0.62	0.13	0.31	11.67	164.3
Quadratic	5	0.59	0.26	0.51	3.96	498.2
Env x densities x among 1	40	12.70**	0.40	0.96*	5.71	1839.7**
Linear	20	22.65**	0.37	1.02*	6.79	2147.8**
Quadratic	20	2.74	0.44	0.90	4.64	1481.7*
Env x densities x among 2	30	2.56	0.40	0.96*	6.27	1461.7*
Linear	15	1.75	0.39	0.74	5.49	1324.7
Quadratic	15	3.50	0.35	1.19*	8.05	1598.6*
Env x densities x among 3	40	1.30	0.40	0.74	8.06*	877.7
Linear	20	1.39	0.17	0.92	12.22**	985.3
Quadratic	20	1.22	0.55	0.55	3.90	770.1
Env x densities x among 4	30	49.52**	0.53*	1.57**	4.83	1174.6
Linear	15	4.81*	0.49	1.34**	6.44	991.9
Quadratic	15	5.20*	0.58	1.99**	3.31	1357.3

Source of variations	Degrees of freedom	Silking date	Shedding date	(Silking date-shedding date)+10
Among selections[b]	19	3.58**	3.45**	1.41**
Group 0 vs (1&2&3&4)	1	18.73**	5.90**	3.44**
(1&2) vs (3&4)	1	1.14	4.63**	1.24*
1 vs 2	1	0.50	2.61**	0.87
3 vs 4	1	11.42**	1.90**	3.76**

Table 23 (Continued)

Source of variations	Degrees of freedom		Mean squares		
			Silking date	Shedding date	(Silking date-shedding date)+10
Among 0		1	3.04**	0.08	3.92**
Among 1		4	3.15**	5.40**	0.70*
Among 2		3	0.97*	2.89**	0.78*
Among 3		4	6.37**	6.02**	2.00**
Among 4		3	0.96*	2.17**	1.58**
Densities x among selection	38		0.35**	0.29	0.23
Densities x {0 vs (1&2&3&4)}	2		0.26	0.54	0.08
Linear		1	0.43	1.00*	0.15
Quadratic		1	0.08	0.09	0.00
Densities x {(1&2) vs (3&4)}	2		0.09	0.51	0.17
Linear		1	0.15	0.75*	0.21
Quadratic		1	0.03	0.27	0.13
Densities x (1 vs 2)	2		0.05	0.51	0.33
Linear		1	0.09	0.22	0.03
Quadratic		1	0.01	0.79*	0.62
Densities x (3 vs 4)	2		0.14	0.09	0.07
Linear		1	0.27	0.17	0.04
Quadratic		1	0.02	0.02	0.11
Densities x among 0	2		0.54	0.38	0.03
Linear		1	1.08*	0.75*	0.01
Quadratic		1	0.00	0.01	0.04
Densities x among 1	8		0.26	0.07	0.22
Linear		4	0.17	0.40	0.15
Quadratic		4	0.31	0.09	0.40
Densities x among 2	6		0.24	0.60*	0.30
Linear		3	0.43	0.37	0.30
Quadratic		3	0.05	0.36	0.27

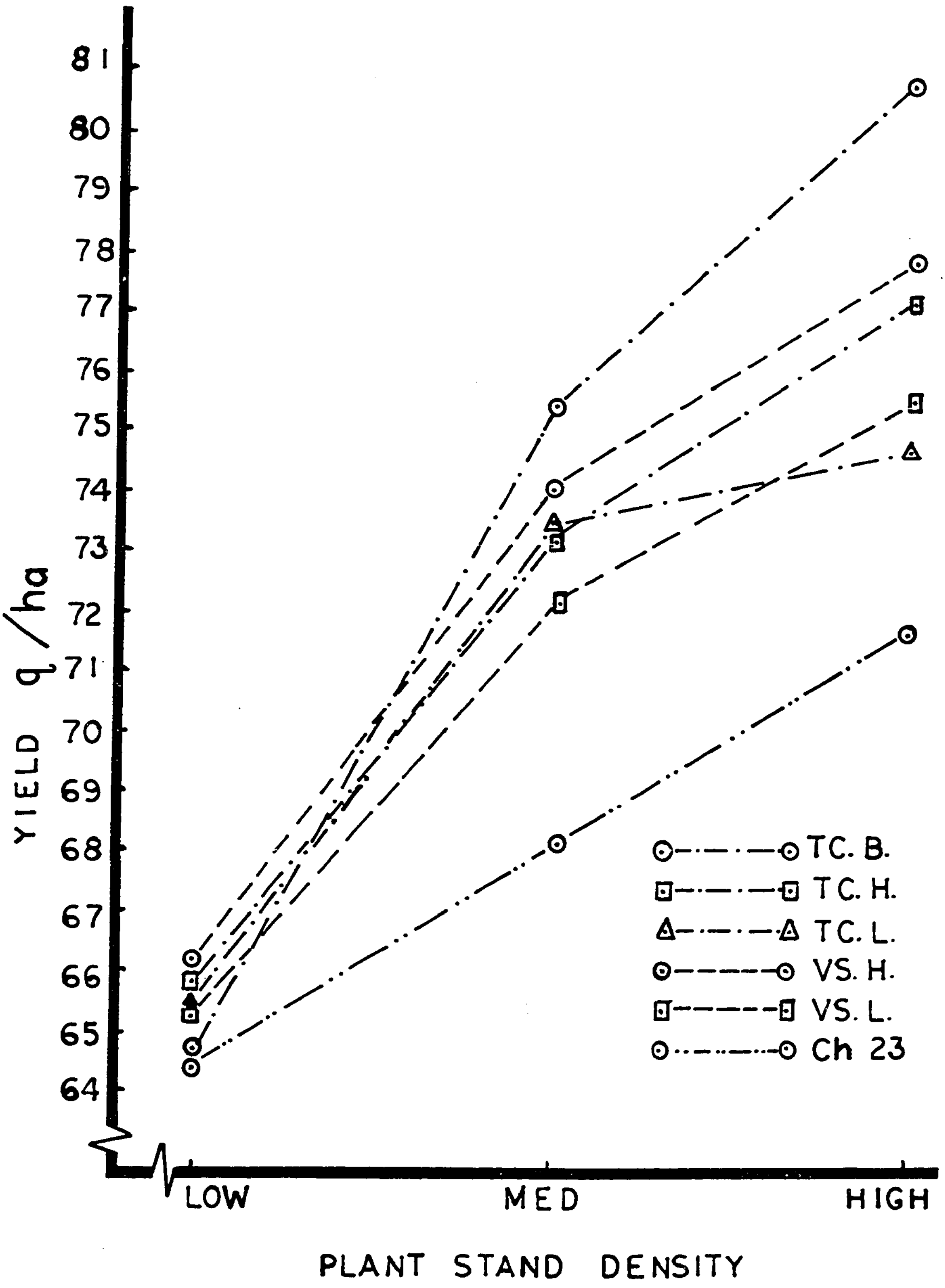
Table 23 (Continued)

Source of variations	Degrees of freedom	Mean squares: Silking date	Mean squares: Shedding date	Mean squares: (Silking date-shedding date)+10
Densities x among 3	8	0.44*	0.09	0.43
Linear	4	0.77**	0.11	0.73*
Quadratic	4	0.10	0.07	0.12
Densities x among 4	6	0.68**	0.57*	0.09
Linear	3	1.18**	0.91*	0.02
Quadratic	3	0.18	0.23	0.18
Env x among selections	38	0.81**	1.06**	0.38*
Env x {group 0 vs (1&2&3&4)}	2	0.14	0.01	0.11
Env x {(1&2) vs (3&4)}	2	0.89*	0.24	0.33
Env x (1 vs 2)	2	2.13**	2.57**	0.03
Env x (3 vs 4)	2	0.18	1.00**	0.33
Env x among 0	2	1.02*	0.89*	0.02
Env x among 1	8	0.65*	1.34**	0.40
Env x among 2	6	0.29	0.40	0.33
Env x among 3	8	1.61**	2.03**	0.60*
Env x among 4	6	0.36	0.26	0.50
Env x densities x among selection	76	0.19	0.26*	0.22
Env x densities x {0 vs (1&2&3&4)}	4	0.51	0.52*	0.11
Linear	2	0.72	0.98**	0.13
Quadratic	2	0.31	0.07	0.10
Env x densities x {(1&2) vs (3&4)}	4	0.07	0.16	0.16
Linear	2	0.06	0.31	0.23
Quadratic	2	0.08	0.02	0.10
Env x densities x (1 vs 2)	4	0.18	0.17	0.01
Linear	2	0.06	0.04	0.01
Quadratic	2	0.32	0.30	0.02

Table 23 (Continued)

Source of variations	Degrees of freedom		Mean squares Silking date	Shedding date	(Silking date-shedding date)+10
Env x densities x (3 vs 4)	4		0.58	0.28	0.21
Linear		2	0.42	0.04	0.24
Quadratic		2	0.75	0.53	0.19
Env x densities x among 0	4		0.10	0.25	0.12
Linear		2	0.07	0.48	0.17
Quadratic		2	0.14	0.02	0.07
Env x densities x among 1	16		0.17	0.16	0.14
Linear		8	0.09	0.11	0.14
Quadratic		8	0.25	0.20	0.14
Env x densities x among 2	12		0.06	0.22	0.20
Linear		6	0.04	0.13	0.20
Quadratic		6	0.09	0.32	0.18
Env x densities x among 3	16		0.26	0.27	0.27
Linear		8	0.32	0.33	0.41
Quadratic		8	0.20	0.23	0.14
Env x densities x among 4	12		0.22	0.40*	0.43*
Linear		6	0.30	0.73**	0.70*
Quadratic		6	0.15	0.03	0.20

Figure 2. Mean testcross yields of five breeding groups and (C103xM14) at three plant densities, data averaged over six environments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Ch 23

superiority in yield performance of the groups as compared with the testcross of M14xC103 is evident in Figure 2.

Group 0 had the highest mean yield, primarily because of its greater yield at the high plant density. The orthogonal comparison of group 0 vs groups 1, 2, 3, 4 x densities-linear was highly significant. Group 0 has two selections that were developed on the basis of testcross performance at both high and low stand densities. The group 2 testcrosses of lines developed on the basis of testcross performance at low stand density had the lowest linear value, but the differences among groups 1, 2, 3, and 4 for linear response did not give a significant F test. Differences among testcrosses for linear values were greater in groups 3 and 4, the visually selected lines, than in groups 1 and 2, the testcross selected lines.

The differences between group 0 and groups 1, 2, 3, 4, and between groups 3 and 4 were not consistent among environments. The interaction of environments x among selections within groups was not significant for group 0, significant for group 2, and highly significant for groups 1, 3, and 4. Second order interactions were relatively unimportant.

For the other plant and ear characters, the analyses of variance showed significant and highly significant F tests for most of the comparisons between groups and among testcrosses within groups. First order interactions involving environments and testcrosses were important for most characters except ears per plant, plant height, and ear diameter. First order interactions of densities with testcrosses were generally of lesser importance than environments x testcrosses interactions. There were only a few instances of significant, or highly significant, second order interactions.

Phenotypic and genotypic correlation coefficients between yield and the 12 agronomic characters for 23 testcrosses are presented in Table 24. These values were calculated from combined analyses of covariance over all environments. The highest phenotypic and genotypic correlations were obtained between yield and number of ears per plant. Ears per plant varied among testcrosses because of barrenness, rather than the production of more than one ear per plant, and barrenness was most prevalent at the highest plant density (Table 65 of the Appendix). Probably there was a close relationship among the characters ear diameter, kernel depth, and shelling percent, and each of these characters had highly significant phenotypic correlations with yield; the importance of ear length to yield, however, was less. There were highly significant differences among testcrosses for kernel weight, but this character had no relationship to yield. Number of seeds per plant, which would be determined partly by number of ears per plant, had highly significant phenotypic correlations with yield. Although there were important differences among the testcrosses for plant and ear heights (Table 21), these had no significant effect on yield. Maturity, on the basis of dates of pollen shedding and silk emergence, had no significant relationship with yield; the difference between pollen shedding and silk emergence dates, however, had a significant relationship with yield. Since the association was negative, it shows that as the silking date relative to shedding date was delayed, the yield was decreased. Actually, the delay in silk emergence was probably effective in causing barrenness, and there was a high, positive

Table 24. Phenotypic (r_{ph}) and genotypic (r_g) correlation coefficients between yield and 12 agronomic characters for 20 entries and three checks, data summarized over six environments

Characters	r-values[a] with yield r_{ph}	r_g
Plant height	0.19	0.19
Ear height	0.33	0.37
No. ear/plant	0.76**	0.83
Ear length	0.49*	0.45
Ear diameter	0.68**	0.68
Kernel depth	0.59**	0.59
Shelling percent	0.62**	0.64
300-kernel weight	0.04	0.00
No. seed/plant	0.60**	0.58
Silking date	-0.04	-0.04
Shedding date	0.30	0.34
(Silking date-shedding date)+10	-0.51*	-0.56

[a]r-values for 21 degrees of freedom at probability level of:
5% = 0.41; *significant differences,
1% = 0.53; **highly significant differences.

relationship between yield and number of ears per plant. In general, genotypic correlations were of greater magnitude than were the phenotypic correlations.

Phenotypic correlation coefficients between yield and 12 plant and ear characters for testcrosses of the 20 selections were calculated at each stand density and for the testcross means over all densities. The r-values are given in Table 25. The magnitude of the r-values and number of significant r-values increased as the stand density increased. Generally, the r-values based on the testcross mean values over all densities were less than the r-values for the high density but greater than for either the low or intermediate densities. At the low stand level, only plant and ear heights were significantly correlated with yield.

At the intermediate density, ear diameter and shelling percentage, in addition to plant and ear height, were significantly correlated with yield. At the high density, all characters except 300-kernel weight, silking date, and pollen shedding date were correlated significantly, or highly significantly, with yield. The highest r-value was between yield and ears per plant at the high density. The effect of ears per plant was actually an effect of barrenness because there were few second ears on any of the testcrosses, even at the low density. The correlation between yield and delay of silk emergence relative to pollen shedding was negative and highly significant. Probably the delayed silking enhanced barrenness.

Table 25. Phenotypic correlation coefficients between grain yield and 12 agronomic characters for testcrosses of 20 selections, data summarized over environments

Characters[b]	r-values[a] with grain yield			
	Low[c]	Medium	High	Mean
Plant height	0.51*	0.44*	0.56**	0.58**
Ear height	0.47*	0.51*	0.54*	0.20
No. ear/plant	0.29	0.40	0.84**	0.71**
Ear length	0.38	0.23	0.72**	0.39
Ear diameter	0.21	0.50*	0.81**	0.68**
Kernel depth	0.13	0.41	0.70**	0.53*
Shelling percent	0.39	0.47*	0.72**	0.54*
300-kernel weight	-0.01	0.33	0.01	0.19
No. seed/plant	0.31	0.37	0.69**	0.47*
Silking date	0.33	0.10	-0.33	0.04
Shedding date	0.29	0.42	0.14	0.46*
(Silking date-shedding date)+10	-0.04	-0.42	-0.66**	-0.66**

[a] r-values for 18 degrees of freedom at probability level of:
5% = 0.44; *significant differences,
1% = 0.56; **highly significant differences.

[b] Six environments for the first nine characters and three environments for the last three characters.

[c] Plant densities.

It is obvious from the data in Table 25 that valuable information may not be obtained if the correlation coefficients are calculated only for the testcross means over all densities. For example, ear height and yield had an r-value of 0.20 based on testcross means over all densities, but at the individual densities all r-values were high enough to be significant. Also, ear length and yield were not significantly correlated on the testcross mean basis, but at the high density the r-value was highly significant. In contrast, however, yield and pollen shedding date had a significant r-value on the testcross mean basis but not at any of the individual plant densities.

The relationships among all characters of the testcrosses for the 20 selections, except silking and shedding dates and their difference, were studied by calculating the phenotypic correlation coefficients at each plant density and for the mean over all densities. Correlation coefficients are presented in Table 26. Generally, as the plant density increased the magnitude and number of significant correlation coefficients increased, indicating more dependent relationships among the characters at the level of greater environmental stress to the individual plant.

Cob length measurements of M14, C103, and the 20 selected inbreds were taken during the 15 days preceding silk emergence to study the relationship of this character to yield of testcrosses. Final cob length means at silk emergence for the two top ears and linear regression coefficients for log of cob length at 3-day intervals in the 15-day period preceding silk emergence, data summarized over two years, are presented in Table 27. Similar data for the individual years are given in Table 79

Table 26. Phenotypic correlation coefficients among agronomic characters of 20 entries, data summarized for each plant density and over all densities combined over six environments

		r-values[a] for characters							
Characters	Densities	Ear height	Ear/plant	Ear length	Ear diameter	Kernel depth	Shelling percent	300-kernel weight	No. seed per plant
Plant height	Low	0.80**	-0.19	0.05	0.03	0.24	0.24	0.18	-0.19
	Medium	0.75**	-0.07	0.04	0.03	0.21	0.09	0.36	0.10
	High	0.72**	0.32	0.25	0.36	0.41	0.31	0.38	0.00
	Mean	0.72**	-0.02	0.08	0.20	0.32	0.10	0.53*	-0.11
Ear height	Low		-0.05	0.09	0.07	0.27	0.05	-0.02	-0.10
	Medium		0.07	0.26	-0.03	0.18	0.05	0.23	0.21
	High		0.35	0.37	0.36	0.45*	0.30	0.08	0.22
	Mean		-0.29	0.19	-0.08	0.08	-0.01	0.23	-0.09
Ear/plant	Low			0.11	0.64**	0.17	0.00	0.07	0.13
	Medium			0.00	0.62**	0.33	0.18	-0.06	0.25
	High			0.64**	0.93**	0.81**	0.78**	-0.13	0.76**
	Mean			0.22	0.85**	0.54*	0.50*	-0.06	0.52*
Ear length	Low				-0.54*	-0.73**	-0.09	0.14	0.09
	Medium				-0.48*	-0.58**	-0.01	-0.09	0.17
	High				0.44*	0.22	0.47*	-0.33	0.74**
	Mean				-0.11	-0.39	0.05	-0.11	0.33
Ear diameter	Low					0.75**	0.22	0.03	0.14
	Medium					0.73**	0.42	0.17	0.19
	High					0.90**	0.69**	-0.07	0.67**
	Mean					0.72**	0.49*	0.01	0.43

[a]r-values for 18 degrees of freedom at probability level of:
5% = 0.44; *significant differences,
1% = 0.56; **highly significant differences.

Table 26 (Continued)

Characters	Densities	r-values[a] for characters Ear height	Ear/ plant	Ear length	Ear diameter	Kernel depth	Shelling percent	300-kernel weight	No. seed per plant
Kernel depth	Low						0.37	-0.19	0.06
	Medium						0.56**	0.32	-0.05
	High						0.74**	0.17	0.47*
	Mean						0.59**	0.32	0.07
Shelling percent	Low							-0.26	0.34
	Medium							-0.09	0.33
	High							0.04	0.56**
	Mean							-0.05	0.39
300-kernel weight	Low								-0.70**
	Medium								-0.69**
	High								-0.61**
	Mean								-0.77**

Table 27. Cob lengths for the two top ears of the inbred lines at date of silking, ratio of second to top cobs, and linear regression coefficients of log cob length during 15 days preceding silk emergence, data summarized over two years

	Entry no.	Top cob L_1[a]	b_1[b]	Second cob L_2[a]	b_2[b]	Ratio L_2/L_1
HP group						
	01	12.1	0.067	6.1	0.057	0.50
	02	13.3	0.064	9.6	0.061	0.72
	03	13.9	0.063	9.4	0.058	0.68
	04	14.2	0.073	9.9	0.070	0.70
	05	13.6	0.065	9.7	0.061	0.71
	06	11.2	0.062	5.1	0.042	0.46
	07	14.7	0.071	11.4	0.070	0.78
	08	13.5	0.059	7.9	0.056	0.59
	09	14.7	0.059	9.2	0.054	0.63
	10	14.0	0.066	10.6	0.064	0.76
	$\bar{x}$	13.5	0.065	8.9	0.059	0.66
LP group						
	11	14.4	0.066	8.6	0.051	0.60
	12	11.5	0.061	8.0	0.055	0.70
	13	12.7	0.052	8.5	0.050	0.67
	14	14.1	0.063	10.8	0.061	0.77
	15	13.4	0.051	7.1	0.042	0.53
	16	14.9	0.058	7.6	0.050	0.51
	17	15.1	0.059	10.2	0.056	0.68
	18	13.1	0.060	10.9	0.061	0.83
	19	17.5	0.069	11.0	0.061	0.63
	20	14.3	0.064	8.5	0.060	0.59
	$\bar{x}$	14.1	0.060	9.1	0.055	0.65
Checks						
	21	13.4	0.073	9.7	0.064	0.72
	22	13.5	0.058	2.8	0.031	0.21

[a]Cob lengths at silking date in cm.

[b]Linear regression coefficients.

of the Appendix. Groups means for two methods of classifying the lines, data summarized over two years, are given in Table 28 and for the individual years in Table 80 of the Appendix.

Table 28. Cob lengths for the two top ears of groups of inbred lines at silking date, ratio of second to the top cob, and linear regression coefficients of log cob length during 15 days preceding silk emergence, data summarized over two years

Group	Top cob		Second cob		Ratio
	L_1[a]	b_1[b]	L_2[a]	b_2[b]	L_2/L_1
Selection basis					
HP	13.5	0.065	8.9	0.059	0.66
LP	14.1	0.060	9.1	0.055	0.65
Method of breeding					
0	12.7	0.065	7.9	0.059	0.62
1	13.3	0.064	8.5	0.056	0.64
2	13.1	0.061	8.6	0.055	0.66
Mean (TC)	13.0	0.063	8.3	0.057	0.64
3	14.7	0.063	10.0	0.059	0.68
4	14.6	0.061	9.3	0.058	0.64
Mean (VS)	14.7	0.062	9.7	0.059	0.66
Checks					
M14	13.4	0.073	9.7	0.064	0.72
C103	13.5	0.058	2.8	0.031	0.21

[a]Cob lengths at silking date in cm.

[b]Linear regression coefficients.

Analyses of variance for data combined over years, with orthogonal comparisons made on the two methods of grouping the lines, are shown in Tables 29 and 30 and for individual years in Tables 77 and 78 of the Appendix. Average cob length of the two top cobs at 3-day intervals

Table 29. Combined analyses of variance of log cob length with time for the two top ears during the two weeks preceding silking for 20 inbred lines and two checks, data summarized over two years

Source of variations	Degrees of freedom			Mean squares: Top cob[a]	Mean squares: Second cob[a]
Environments	1			192.8**	403.3**
Reps/environments	8			6.3	6.3
Entries[b]	21			19.4*	95.1**
Environments x entries	21			8.0	12.0
Error (a)	168			8.3	8.3
Dates	5			5695.0**	4745.8**
Linear			1	28256.7**	23418.4**
Reminder			4	54.6	77.6*
Environments x dates	5			18.1**	11.5
Entries x dates	105			4.1	7.6**
Entries x dates linear		21		9.0*	23.8**
(Selections vs checks) x dates$_{\ell}$		1		2.4	70.7**
(Among selections) x dates$_{\ell}$		19		8.6**	13.4**
(HP vs LP) x dates$_{\ell}$			1	29.4**	43.4**
(Among HP) x dates$_{\ell}$			9	6.9*	10.4**
(Among LP) x dates$_{\ell}$			9	8.1*	13.0**
(Among checks) x dates$_{\ell}$		1		22.7**	175.7**
Entries x dates remainder		84		2.8	3.6
Environments x entries x dates	105			3.2	3.4
Error (b)	880			4.1	5.7
Total	1319				

[a]Observed values were multiplied by 10^3.

[b]Orthogonal comparisons based on reasons lines were selected for the study (Table 1).

Table 30. Combined analyses of variance of log cob length with time for the two top ears during the two weeks preceding silking for 20 inbred lines and two checks, data summarized over two years

Source of variations	Degrees of freedom				Mean squares Top cob[a]	Mean squares Second cob[a]
Environments	1				192.8**	403.3**
Reps/environments	8				6.3	6.3
Entries[b]	21				19.4*	95.1**
Environments x entries	21				8.0	12.0
Error (a)	168				8.3	8.3
Dates	5				5695.0**	4745.8**
Linear				1	28256.7**	23418.4**
Reminder				4	54.6	77.6*
Environments x dates	5				18.1**	11.5
Entries x dates	105				4.1	7.6**
Entries x dates linear		21			9.0*	23.8**
(Selection vs check) x dates$_\ell$			1		2.4	70.7**
(Among selection) x dates$_\ell$			19		8.6**	13.4**
{0 vs (1&2&3&4)} x dates$_\ell$				1	2.0	1.0
{(1&2) vs (3&4)} x dates$_\ell$				1	2.6	9.9
(1 vs 2) x dates$_\ell$				1	3.0	19.5*
(3 vs 4) x dates$_\ell$				1	0.1	0.1
Among 0 x dates$_\ell$				1	1.4	0.4
Among 1 x dates$_\ell$				4	23.9**	31.7**
Among 2 x dates$_\ell$				3	3.3	4.7
Among 3 x dates$_\ell$				4	4.7	5.9
Among 4 x dates$_\ell$				3	10.3*	19.7*
(Among check) x dates$_\ell$			1		22.7**	175.7**
Entries x dates remainder		84			2.8	3.6
Environments x entries x dates	105				3.2	3.4
Error (b)	880				4.1	5.7
Total	1319					

[a]Observed values were multiplied by 10^3.

[b]Orthogonal comparisons based on breeding groups.

during the 15-day period preceding silking of each of 20 lines and M14 and C103 for 1966 and 1967 are presented in Tables 75 and 76 of the Appendix, respectively.

Differences among entries were significant at the five percent level for the top ear and at the one percent level for the second ear. However, since this comparison is actually for the average cob length over all sampling dates, it has little value. The linear component accounted for most of the variations among the six dates of sampling. The most important part of the combined analysis is the interaction of entries x dates-linear which is actually a test of the difference in growth rates among the lines. It tests the differences among lines for the linear regression values. In the interaction of selections vs checks x dates-linear, the F value was not significant for the top cob, but was highly significant for the second cob. The poor development of the second cob in C103 probably caused this significant interaction. None of the selections had a second cob as short as C103, but several lines had second cobs shorter than M14 (Table 27). All orthogonal comparisons involving the selected lines with dates-linear, Table 29, gave significant, or highly significant, F tests for both top and second cobs. In all cases, effects were greater for the second cob than for the top cob. Although the rate of growth for both cobs was greater for the HP group than for the LP group, cob lengths at silk emergence were slightly more for the LP group.

The analyses of variance based on the breeding groups of lines, Table 30, showed that most of the variation for selections x dates-linear was due to differences among lines in groups 1 and 4. Differences among groups were relatively unimportant. None of the groups had growth rates as high as M14, but all had growth rates higher than C103 (Table 28).

In addition to analyzing the measurements over all dates, the cob length for the last date was analyzed, which was at silk emergence. These analyses for individual years are in Table 81 of the Appendix and are presented for the combined data in Table 31. These measurements were for six plants per plot in the first year and 12 plants per plot for the second year and five replications per test. The differences between the HP and LP groups were not significant for either cob; differences among lines within groups were significant or highly significant. The relative values were consistent for the two years in which measurements were made.

Table 31. Part of the combined analyses of variance of the top and the second cob final length at silking date, data summarized over two environments

Source of variations	Degrees of freedom	Mean squares: Top ear	Mean squares: Second ear
Entries	21	353.8**	866.5**
Selections vs checks	1	53.9	2755.0**
Among selection[a]	19	388.2**	565.8**
HP vs LP	1	336.4	60.0
Among HP	9	251.6*	766.4**
Among LP	9	530.6**	421.3**
Among checks	1	1.0	4692.3**
Environments x entries	21	85.4	82.4
Env x (selections vs checks)	1	40.8	32.2
Env x (among selection)	19	89.7	89.0
Env x (HP vs LP)	1	48.4	0.0
Env x (among HP)	9	35.2	100.7
Env x (among LP)	9	148.8	87.2
Env x (among checks)	1	49.0	6.3
Error	168	109.0	60.4

[a]Orthogonal comparisons based on reasons lines were selected for the study (Table 1).

When these data were analyzed on the basis of breeding groups, some significant group differences were obtained in the combined analyses as shown in Table 32 and in analysis for individual environments (Table 82 of the Appendix).

Table 32. Part of the combined analyses of variance of the top and the second cob final length at silking date, data summarized over two environments

Source of variations	Degrees of freedom	Mean squares: Top ear	Mean squares: Second cob
Entries	21	353.8**	866.5**
Selections vs checks	1	53.9	2755.0**
Among selection[a]	19	388.2**	565.8**
0 vs (1&2&3&4)	1	572.5*	590.3*
(1&2) vs (3&4)	1	1849.0**	1156.0**
1 vs 2	1	12.8	5.4
3 vs 4	1	15.2	241.7
Among 0	1	144.0	1190.3**
Among 1	4	304.2*	1086.4**
Among 2	3	342.3*	66.3
Among 3	4	560.6**	245.0*
Among 4	3	98.8	680.5**
Among checks	1	1.0	4692.3**
Environments x entries	21	85.4	82.4
Env x (selections vs checks)	1	40.8	32.2
Env x (among selection)	19	89.7	89.0
Env x {0 vs (1&2&3&4)}	1	8.1	4.2
Env x {(1&2) vs (3&4)}	1	7.1	18.8
Env x (1 vs 2)	1	405.4	117.9
Env x (3 vs 4)	1	224.1	25.1
Env x (among 0)	1	81.0	90.3
Env x (among 1)	4	123.7	148.9*
Env x (among 2)	3	47.5	33.5
Env x (among 3)	4	44.6	170.5*
Env x (among 4)	3	54.3	19.1
Env x (among checks)	1	49.0	6.3
Error	168	109.0	60.4

[a]Orthogonal comparisons based on breeding groups.

Groups 1 and 2, selected on the basis of testcross performance, had shorter cobs than groups 3 and 4, selected on the basis of visual appearance (Table 28), and these differences were highly significant for both cobs (Table 32). Group 0 had the shortest cobs and group 3, selected at high stand densities, had the longest cobs.

Additional data given in Tables 27 and 28 are the ratios for second cob length to first cob length at silk emergence. Generally, these values are an indication for second cob growth because differences among lines were greater for second cobs than for top cobs. Although the difference between the HP and LP groups was very small, there were much larger differences among lines within groups. Differences between breeding groups were relatively larger; however, in neither of the groups were there ratio differences as great as between C103 and M14.

The phenotypic correlation coefficients between inbred ear characters and average yield performance of the inbreds in testcrosses are presented in Table 37. The relationship between cob growth rates and yield were highly significant. Actual cob length differences of the lines, however, showed no important relationship to testcross yields.

Table 33 shows cob length data for some of the lines selected because of their differences in second ear development. Entries 1, 6, 15, and 16 had the lowest L_2/L_1 ratio, short second cobs, and relatively low second cob development. In contrast, entries 7, 10, 14, and 18 had the highest L_2/L_1 ratio, long second cobs, and relatively fast second cob development. Entries 17 and 19 were intermediate. The average testcross yields of the lines in Table 33 are presented in Table 34 for the three stand densities over six environments. The highest yielding testcross, entry 10, had strong second cob growth and practically no barrenness; the lowest yielding testcross, entry 16, had less second cob growth and considerable barrenness in the high stand density. Also, C103 testcross had low average yield; inbred C103 had very poor second cob growth development and had 15 percent barren plants at the high density. Except for these three lines, the relationship between cob development of the inbred and barrenness and yield of the testcross was not consistent.

Table 33. Cob lengths of some selected inbred lines for the two top ears, ratio of the second to the top cobs, and regression coefficients of log cob length during 15 days preceding silk emergence, data summarized over two environments

	Top cob		Second cob		Ratio
Entry no.	L_1[a]	b_1[b]	L_2[a]	b_2[b]	L_2/L_1
01	12.1	0.067	6.1	0.057	0.50
06	11.2	0.062	5.1	0.042	0.46
15	13.4	0.051	7.1	0.042	0.53
16	14.9	0.058	7.6	0.050	0.51
07	14.7	0.071	11.4	0.070	0.78
10	14.0	0.066	10.6	0.064	0.76
14	14.1	0.063	10.8	0.061	0.77
18	13.1	0.060	10.9	0.061	0.83
19	17.5	0.069	11.0	0.061	0.63
17	15.1	0.059	10.2	0.056	0.68
M14	13.4	0.073	9.7	0.064	0.72
C103	13.5	0.058	2.8	0.031	0.21

[a]Cob lengths at silking date in cm.

[b]Linear regression coefficients.

Table 34. Average yield for a selected group of entries showing special trend in their cob growth at the inbred level, data summarized for three population levels over six environments

Entry no.	Breeding group	Yield in q/ha Low[a]	Medium	High	Mean	Regression coefficients R_ℓ	R_q
01	0	65.8	77.2	79.9	74.3	7.05	-1.45
06	1	67.5	74.1	79.7	73.8	6.10	-0.17
15	1	62.7	69.5	71.8	68.0	4.55	-0.75
16	4	61.8	66.7	57.2	61.9	-2.30	-2.40
07	4	68.6	76.0	85.7	76.8	8.55	-0.38
10	3	67.2	77.5	91.0	78.6	11.90	-0.53
14	1	66.0	76.5	81.4	74.6	7.70	-0.93
18	3	66.0	74.8	73.5	71.5	3.75	-1.68
19	3	69.9	74.8	76.0	73.6	3.05	-0.62
17	4	64.7	71.4	72.4	69.5	3.85	-0.95
M14	check	65.1	72.8	73.9	70.6	4.45	-1.12
C103	check	57.1	66.9	68.9	64.3	5.90	-1.30
(M14xC103)	ch	64.5	68.1	71.7	68.1	3.60	0.00

[a]Plant densities.

Sharp contrasts between testcrosses of entries 10 and 16 are shown in Table 35. The testcross of entry 10 yielded much higher than the testcross of entry 16, mainly because of the much greater superiority of entry 10 at the highest plant density. Differences between these testcrosses for the ear components were relatively small at the low density, but increased from the low to the high density, except for weight per 300 kernels. In weight per 300 kernels, the difference was greater at the lowest stand density. Testcross of entry 10 had very little delay in silk emergence relative to pollen shedding at all plant densities, but testcross of entry 16 had a 3-day delay at the high density as compared to a 1.7-day delay at the low density. Probably this delay in silk emergence for testcross 16 was the main cause of its high barrenness at the high density.

Table 35. Average performance of the testcross of entries 10, 16, and 23, data of 13 agronomic characters summarized at three densities over six environments

Characters	Entry no.	Plant densities Low	Medium	High	Mean	Regression coefficients R_ℓ	R_q
Yield							
	10	67.2	77.5	91.0	78.6	11.90	-0.53
	16	61.8	66.7	57.2	61.9	-2.30	-2.40
	23	64.5	68.1	71.7	68.1	3.60	0.00
Ear/plant							
	10	0.99	1.00	0.99	0.99	0.000	-0.003
	16	0.96	0.92	0.73	0.87	-0.115	-0.025
	23	0.96	0.95	0.89	0.93	-0.035	-0.008
Ear length (mm)							
	10	196	181	164	180	-15.8	-0.3
	16	203	186	127	172	-37.8	-6.8
	23	192	171	143	169	-24.5	-1.1
Ear diameter (mm)							
	10	51	49	46	49	-2.6	-0.5
	16	47	44	32	41	-7.6	-1.5
	23	49	46	40	45	-4.2	-0.5
Shelling percent							
	10	81.8	82.1	82.5	82.1	0.43	0.05
	16	81.7	81.8	79.6	81.0	-1.05	-0.38
	23	81.7	81.9	81.7	81.8	0.01	-0.05
300-kernel weight (g)							
	10	96.5	87.8	77.4	87.2	-9.53	-0.28
	16	85.8	81.7	74.8	80.8	-5.54	-0.47
	23	85.2	80.6	75.8	80.5	-4.71	-0.05
Kernel depth (mm)							
	10	21	20	18	20	-1.2	-0.3
	16	18	17	12	16	-3.2	-0.6
	23	19	18	16	18	-1.5	-0.3
No. seed/plant							
	10	674	650	588	638	-43.0	-6.4
	16	699	597	384	560	-157.3	-18.5
	23	727	623	473	608	-127.2	-7.6
(Silking date-shedding date) +10	10	10.6	10.2	10.9	10.6	0.14	0.18
	16	11.7	12.1	13.0	12.2	0.67	0.09
	23	10.5	11.0	12.0	11.2	0.77	0.08

Figures 3, 4, 5, and 6 show the cob growth patterns for inbred entries 10, 16, M14, and C103, respectively. Previous studies by Russell and Teich (1967) showed that M14 resisted barrenness at high stand levels whereas C103 had a high degree of barrenness at high stand levels. This difference of M14 and C103 appeared related to their second cob growth rates. The cob growth patterns for entry 10 and entry M14, Figures 3 and 5, were similar in the present study, whereas entry 16 was intermediate between M14 and C103 for the second cob.

Phenotypic correlation coefficients involving cob lengths, regressions, and ratios of cob lengths are presented in Table 36. The high correlation between final cob length and linear regression for the second cob suggests that measurements for cob length at silking would be just as valuable as all the data on cob growth rate.

Data in Table 37 did not show a significant correlation between cob length ratios and testcross yields at any of the three densities or the mean over all densities. However, significant, or highly significant, correlation values of first and second cob growth rates with testcross yields were obtained at the low and high densities and for the mean over all densities. Nonsignificant correlation coefficients were obtained between all inbred characters and the linear regression coefficients of the testcross yields across plant stand densities.

B. Part b)

The purpose of this part of the study was to determine if selection in successive generations of inbred lines was effective in improving combining ability. Since the materials used included one group of lines developed on the basis of phenotypic appearance and a second group

Figure 3. Cob growth patterns of the two top ears for entry 10, values averaged over two years

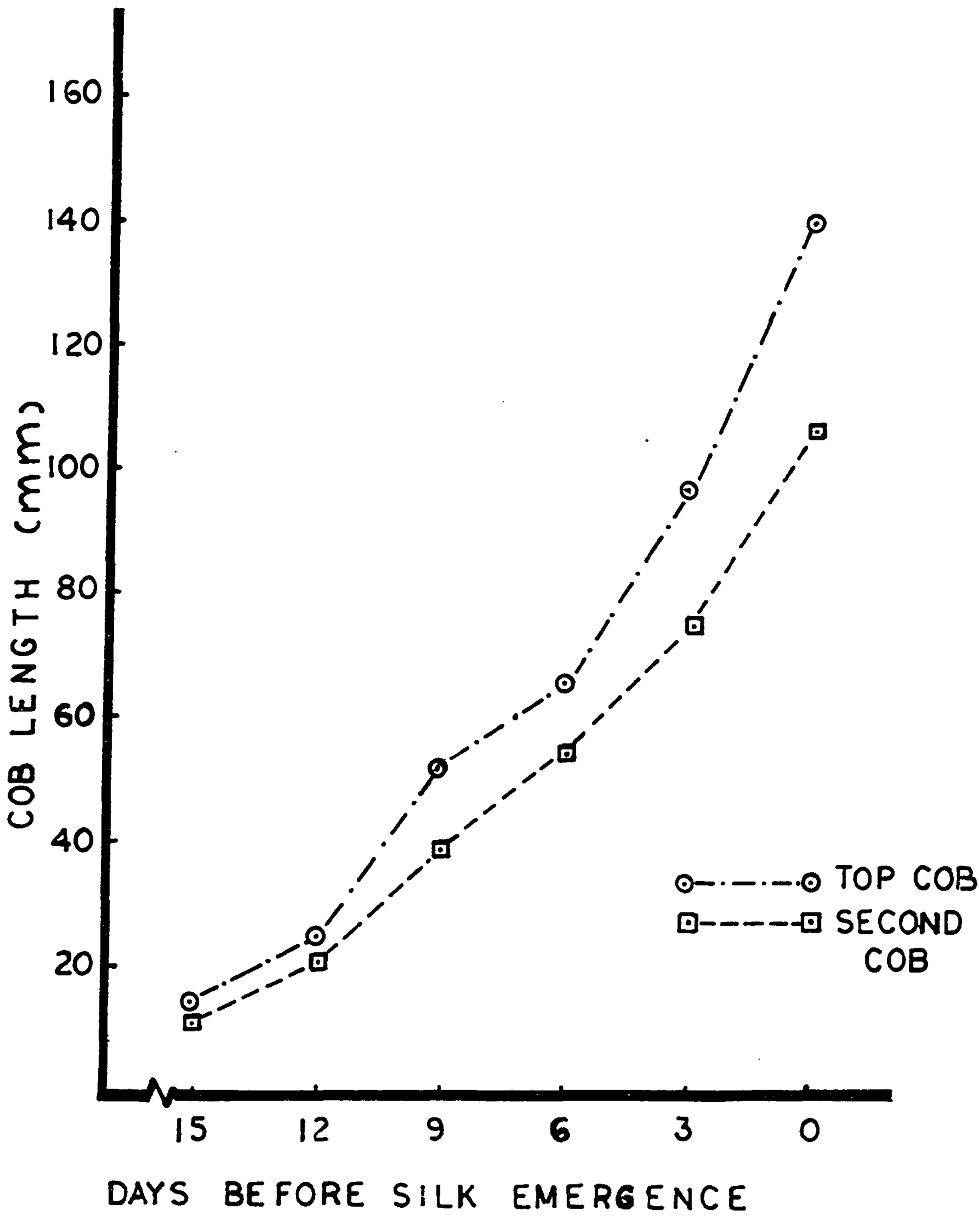
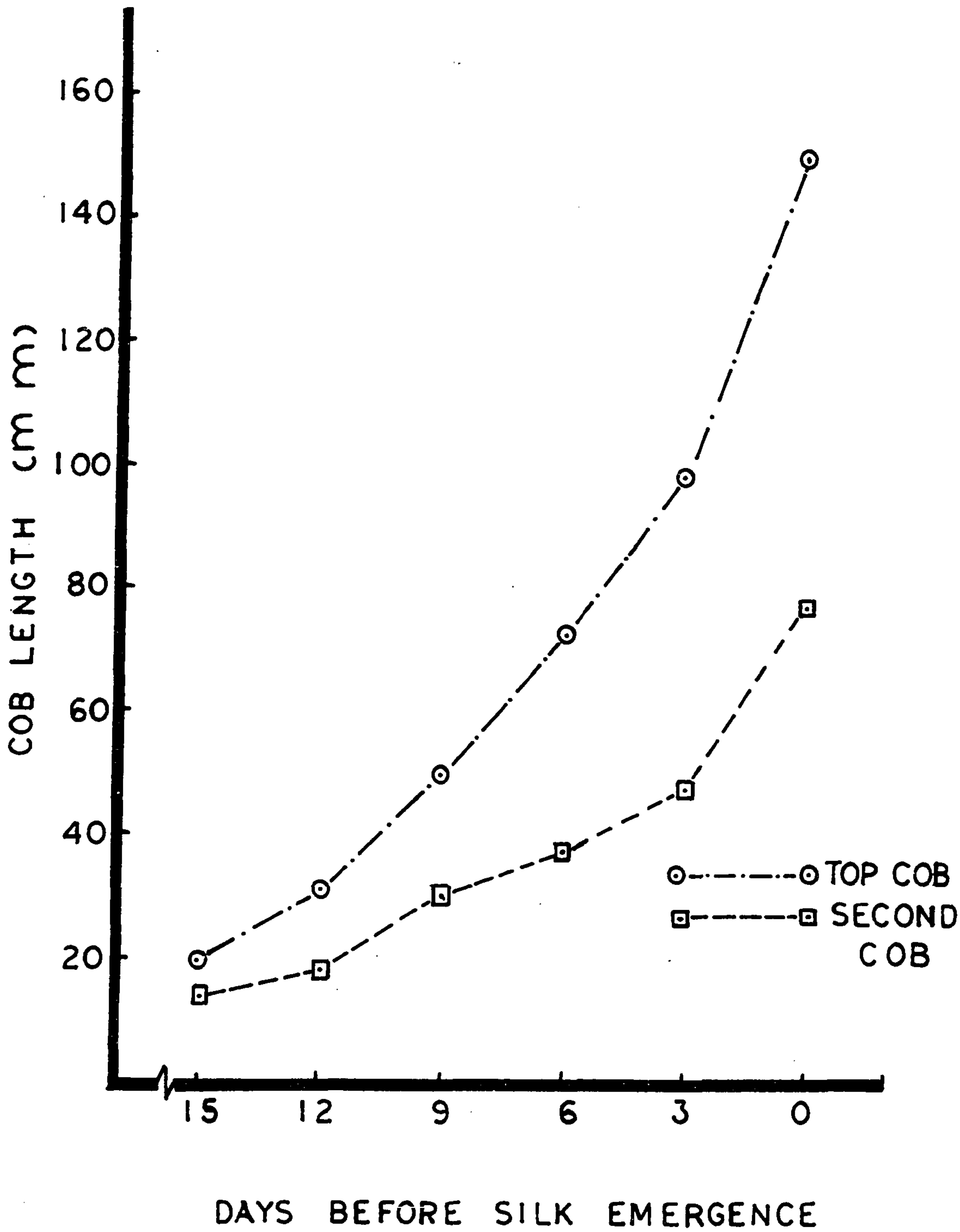

160
140
120
100
80
60
40
20
COB LENGTH (mm)
15
12
9
6
3
0
DAYS BEFORE SILK EMERGENCE
TOP COB
SECOND COB

Figure 4. Cob growth patterns of the two top ears for entry 16, values averaged over two years



160
140
120
100
80
60
40
20
COB LENGTH (m m)
15
12
9
6
3
0
DAYS BEFORE SILK EMERGENCE
TOP COB
SECOND COB

Figure 5. Cob growth patterns of the two top ears for inbred M14, values averaged over two years

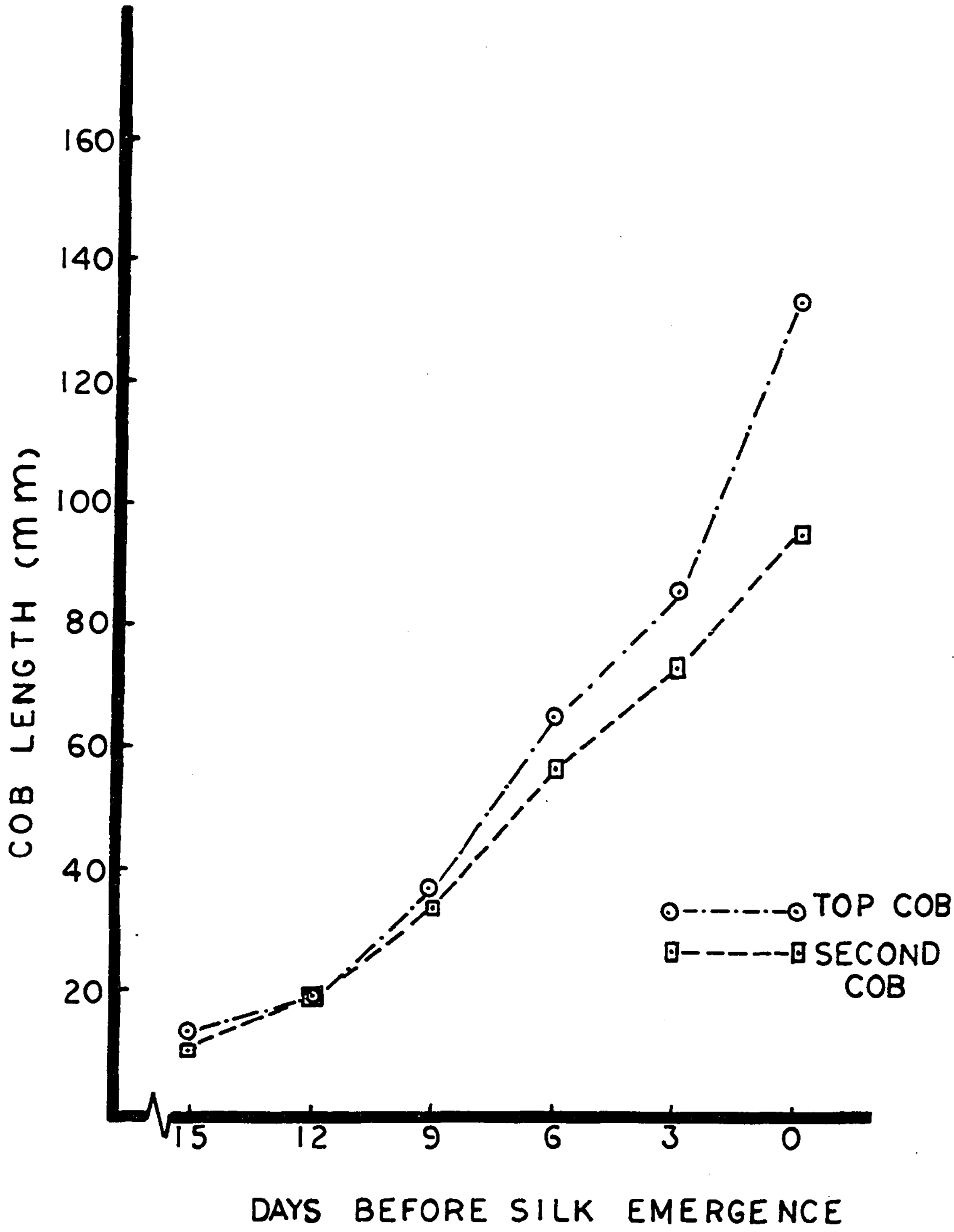

160
140
120
100
80
60
40
20
COB LENGTH (mm)
15
12
9
6
3
0
DAYS BEFORE SILK EMERGENCE
TOP COB
SECOND COB

Figure 6. Cob growth patterns of the two top ears for inbred C103, values averaged over two years

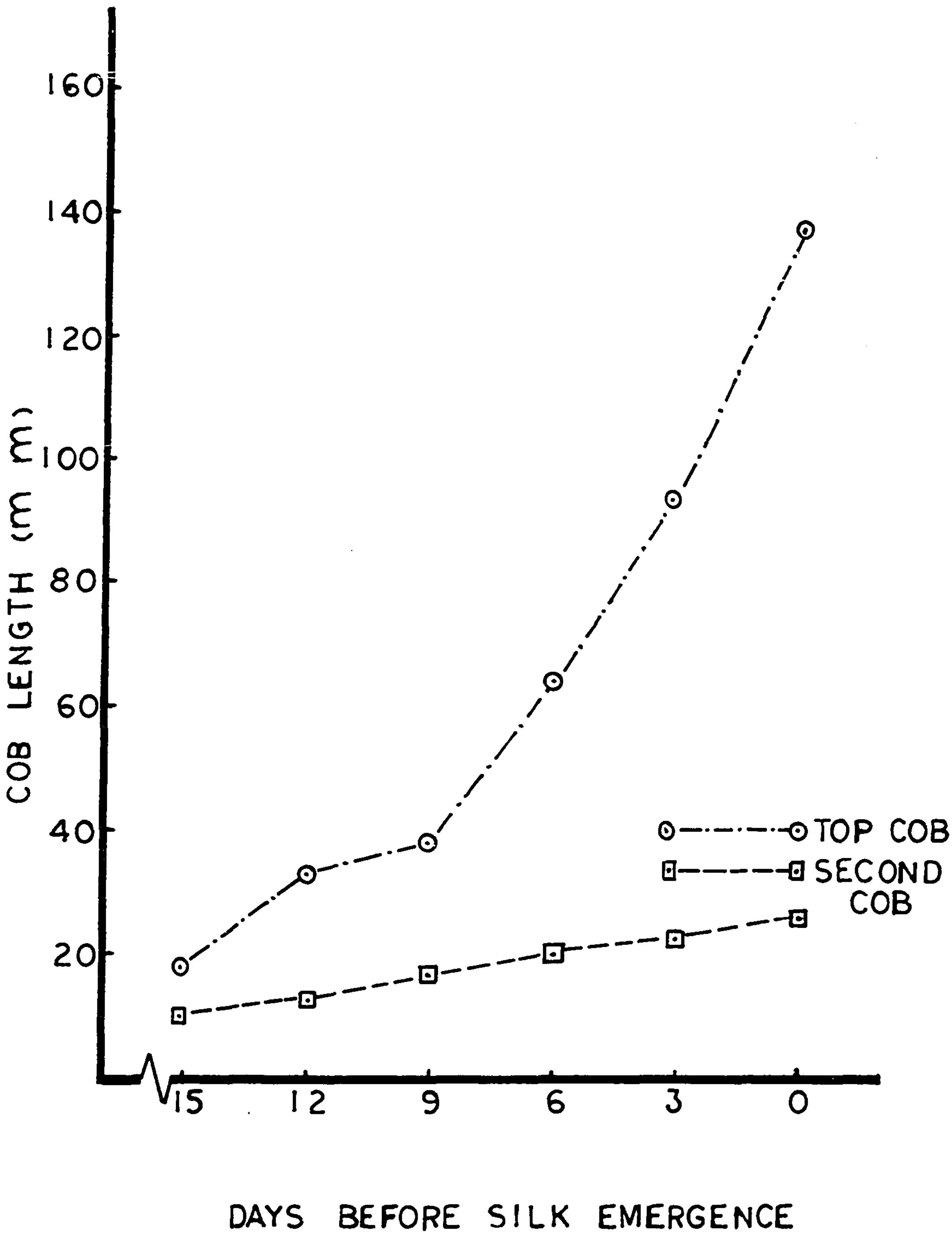

COB LENGTH (m m)
160
140
120
100
80
60
40
20
15
12
9
6
3
0
TOP COB
SECOND COB
DAYS BEFORE SILK EMERGENCE

Table 36. Phenotypic correlation coefficients among the cob growth characteristics of 20 selected inbred lines

Inbred characters[b]	Phenotypic correlation coefficients[a] 1966	1967	Combined over years
L_1 and b_1	0.19	0.33	0.29
L_2 and b_2	0.85**	0.52*	0.76**
b_1 and L_2/L_1	0.10	0.10	0.26
b_2 and L_2/L_1	0.79**	0.46*	0.72**
L_1 and L_2	0.55*	0.62**	0.62**
b_1 and b_2	0.43	0.78**	0.75**

[a]r-values for 18 degrees of freedom at probability level of:
5% = 0.44; *significant differences,
1% = 0.56; **highly significant differences.

[b]L_1 and L_2 are the top and second cob length at silking, respectively; b_1 and b_2 are the top and second cob regression coefficients of the log of the cob length over six dates in the two weeks preceding silking, respectively.

Table 37. Phenotypic correlation coefficients between ear characters of inbred selections and their testcross yields at three plant densities, data summarized for two environments (inbreds) and six environments (testcrosses)

Inbred characters	r-values with testcrosses yield Low[a]	Medium	High	Mean
L_1	0.17	-0.16	-0.08	-0.05
b_1	0.67**	0.35	0.53*	0.64**
L_2	0.35	0.16	0.32	0.34
b_2	0.51*	0.28	0.50*	0.57**
L_2/L_1	0.30	0.28	0.40	0.41

[a]Plant densities.

developed on the basis of testcross performance, there would be an opportunity to compare the progress in the two groups.

Mean yields for the four generations at each of eight environments are presented in Table 38. In five of eight environments the average

Table 38. Average yield in quintals per hectare for each generation at each location

Generation	Kanawha 1968	Martinsburg 1968	Newell 1968	Grundy Center 1968	Ames 1968	Ankeny 1968	Newell 1967	Ames 1967	Mean
Ch[a]	73.3	57.6	69.4	69.2	77.6	73.0	72.6	81.2	71.7
F_2	74.1	54.9	69.3	68.5	74.8	70.5	74.2	82.5	71.1
F_3	75.1	58.0	70.1	70.8	74.6	70.6	76.2	82.8	72.3
F_4	75.9	58.5	71.0	71.5	74.6	70.1	76.1	83.2	72.6
Mean	74.6	57.3	70.0	70.0	75.4	71.1	74.8	82.5	71.9

[a]Check is (M14xC103)(WF9xI205).

yield of the F_2 testcrosses was lower than the testcross of the check, but some yield improvement in the F_3 and F_4 generations was obtained in three of these five environments. In the other three environments an improvement of combining ability as judged by the testcrosses yield was obtained. Martinsburg, 1968, was the lowest yielding environment and Ames, 1967, was the highest yielding environment. The other six environments, however, had relatively similar productivity levels.

Mean yields for testcrosses of 20 families, four generations per family, and their linear and quadratic regression coefficients are presented in Table 39. These are the combined data for eight environments. The combined analyses of variance for yield, with appropriate orthogonal comparisons, are given in Table 41, and the yield data for the individual locations and the analyses of variance are given in Tables 83 and 84 of the Appendix. Mean moisture data for the testcrosses, averaged over all eight environments, are presented in Table 40.

Table 39. Mean yields for testcrosses of four generations in 20 selected families, data averaged for eight environments

	Entry no.	Yield in q/ha				Regression coefficients	
		Ch	F_2[a]	F_3[a]	F_4[a]	R_ℓ	R_q
Group 1[b]							
	01	74.4	73.7	76.2	76.2	0.395	0.175
	02	71.9	73.2	74.4	76.8	0.795	0.275
	03	69.8	73.4	78.2	76.7	1.275	-1.275
	04	74.1	75.9	75.5	74.9	0.100	-0.600
	05	71.2	74.5	73.3	76.4	0.720	-0.050
	$\bar{x}$	72.3	74.1	75.5	76.2	0.655	-0.275
Group 2							
	06	73.0	65.7	70.0	70.3	-0.190	0.190
	07	72.2	61.1	61.0	67.9	-0.650	4.500
	08	73.1	67.9	67.4	64.2	-1.360	0.500
	09	72.1	64.2	66.6	64.4	-1.035	1.425
	10	74.8	69.9	73.6	70.4	-0.475	0.425
	$\bar{x}$	73.0	65.8	67.7	67.4	-0.745	1.725
Group 3							
	11	70.2	72.3	71.8	73.0	0.395	-0.225
	12	70.0	70.2	71.8	75.3	0.875	0.825
	13	73.1	72.9	76.5	75.6	0.555	-0.175
	14	70.7	72.9	74.7	75.2	0.765	-0.429
	15	71.3	76.2	75.9	77.7	0.945	-0.775
	$\bar{x}$	71.1	72.9	74.1	75.4	0.705	-0.125
Group 4							
	16	70.6	72.3	73.3	72.9	0.395	-0.525
	17	67.5	71.3	72.1	69.3	0.310	-1.650
	18	70.2	69.5	72.6	74.6	0.815	0.675
	19	71.3	74.7	69.4	68.6	-0.670	-1.050
	20	72.4	70.2	70.9	71.8	-0.055	0.775
	$\bar{x}$	70.4	71.6	71.7	71.4	0.155	-0.375
Group 1 & 2 mean		72.7	70.0	71.6	71.8	-0.055	0.725
Group 3 & 4 mean		70.8	72.3	72.9	73.4	0.420	-0.250

[a]Generations.

[b]Based on reasons lines were selected for the study (Table 2).

Table 40. Average grain moisture at harvest of four generations in 20 selected families combined over eight environments

	Entry no.	Yield in q/ha				Regression coefficients	
		Ch	F_2[a]	F_3[a]	F_4[a]	R_ℓ	R_q
Group 1[b]	01	24.0	25.1	23.4	23.1	-0.220	-0.350
	02	24.4	25.5	27.0	26.8	0.435	-0.325
	03	24.7	24.7	24.1	24.0	-0.135	-0.025
	04	24.3	25.3	25.4	26.5	0.325	0.025
	05	23.9	24.7	24.0	23.8	-0.050	-0.250
	$\bar{x}$	24.2	25.1	24.8	24.8	0.075	-0.225
Group 2							
	06	24.7	22.9	22.4	22.1	-0.415	0.375
	07	24.6	23.4	24.1	23.7	-0.100	0.200
	08	23.9	24.7	24.5	23.6	-0.055	-0.425
	09	25.0	27.1	27.2	27.2	0.335	-0.525
	10	24.1	22.2	23.3	22.4	-0.200	0.250
	$\bar{x}$	24.5	24.1	24.3	23.8	-0.095	-0.025
Group 3							
	11	24.8	24.5	23.1	23.7	-0.235	0.225
	12	24.4	23.4	22.9	22.9	-0.250	0.250
	13	24.1	24.1	24.8	24.7	0.125	-0.025
	14	24.1	24.0	23.9	23.7	-0.065	-0.025
	15	25.3	27.8	27.8	28.9	0.540	-0.350
	$\bar{x}$	24.6	24.8	24.5	24.8	0.015	0.025
Group 4							
	16	24.4	25.2	25.6	24.6	0.050	-0.450
	17	24.9	23.5	24.1	23.9	-0.120	0.300
	18	24.3	24.4	24.3	23.5	-0.125	-0.225
	19	24.6	25.2	24.1	25.3	0.050	0.150
	20	24.9	23.8	25.0	25.0	0.075	0.275
	$\bar{x}$	24.6	24.4	24.6	24.5	-0.005	0.025
Group 1 & 2 mean		24.4	24.6	24.6	24.3	-0.015	-0.125
Group 3 & 4 mean		24.6	24.6	24.6	24.7	0.015	0.025

[a]Generations.

[b]Based on reasons lines were selected for the study (Table 2).

Table 41. Analyses of variance of yield and moisture for testcrosses of four generations in 20 selected families evaluated in eight environments

Source of variations	Degrees of freedom		Mean squares Yield	Mean squares Moisture
Environments	7		4132.05**	699.93**
Reps/environments	16		122.81**	2.29**
Families[a]	19		245.95**	39.77**
(1&2) vs (3&4)		1	103.93	3.11
1 vs 2		1	2930.02**	26.91**
3 vs 4		1	350.29**	1.28
Among 1		4	10.52	24.39**
Among 2		4	211.98**	69.21**
Among 3		4	77.22**	82.66**
Among 4		4	22.47	4.83**
Environments x families	133		30.00*	1.18**
Environments x {(1&2) vs (3&4)}		7	37.97	0.28
Environments x (1 vs 2)		7	73.01**	0.93
Environments x (3 vs 4)		7	38.70	1.30
Environments x among 1		28	26.98	0.65
Environments x among 2		28	32.34*	1.49**
Environments x among 3		28	25.31	1.09*
Environments x among 4		28	20.47	1.73**
Error (a)	304		21.90	0.70
Generations	3		69.55	0.52
Linear		1	120.71	0.02
Quadratic		1	35.30	1.54
Cubic		1	52.66	0.01
Environments x generations	21		29.98**	0.52
Linear		7	66.22**	1.18*
Quadratic		7	14.98	0.19
Cubic		7	8.73	0.19
Families x generations	57		54.89**	5.17**
{(1&2) vs (3&4)}x generations	3		140.04**	0.83
Linear		1	178.09**	0.10
Quadratic		1	157.11**	2.33*
Cubic		1	84.92*	0.06

[a]Orthogonal comparisons based on reasons lines were selected for the study (Table 2).

Table 41 (Continued)

Source of variations	Degrees of freedom		Mean squares Yield	Moisture
(1 vs 2) x generations	3		412.52**	6.41**
Linear		1	784.14**	9.95**
Quadratic		1	327.04**	1.80
Cubic		1	3.61	7.48**
(3 vs 4) x generations	3		40.25*	1.32*
Linear		1	117.07**	0.66
Quadratic		1	3.61	0.00
Cubic		1	0.07	3.31*
Among 1 x generations	12		20.66	5.69**
Linear		4	31.29	13.86**
Quadratic		4	13.59	1.08
Cubic		4	17.11	2.12**
Among 2 x generations	12		44.85**	6.92**
Linear		4	34.39*	12.28**
Quadratic		4	88.14**	5.57**
Cubic		4	12.02	2.91**
Among 3 x generations	12		11.60	7.06**
Linear		4	8.68	17.14**
Quadratic		4	11.36	1.83*
Cubic		4	14.75	2.20**
Among 4 x generations	12		35.40**	2.77**
Linear		4	48.99**	1.72*
Quadratic		4	36.47*	3.16**
Cubic		4	20.75	3.44**
Environments x families x generations	399		13.30**	0.57*
Env x {(1&2) vs (3&4)} x generations	21		13.45	0.33
Linear		7	10.76	0.44
Quadratic		7	13.98	0.24
Cubic		7	15.61	0.31
Env x (1 vs 2) x generations	21		24.21**	0.72
Linear		7	37.12**	0.63
Quadratic		7	20.56*	0.57
Cubic		7	14.94	0.95
Env x (3 vs 4) x generations	21		13.08	0.52
Linear		7	17.03	0.92
Quadratic		7	9.51	0.31
Cubic		7	12.67	0.32
Env x among 1 x generations	84		9.88	0.56
Linear		28	11.12	0.80*
Quadratic		28	11.51	0.26
Cubic		28	7.02	0.62
Env x among 2 x generations	84		16.52**	0.61
Linear		28	17.44**	0.65
Quadratic		28	19.48**	0.61
Cubic		28	12.66	0.55

Table 41 (Continued)

Source of variations	Degrees of freedom		Mean squares Yield	Mean squares Moisture
Env x among 3 x generations	84		14.00**	0.63*
Linear		28	19.89**	0.95**
Quadratic		28	9.27	0.48
Cubic		28	12.85*	0.43
Env x among 4 x generations	84		10.11	0.54
Linear		28	9.53	0.57
Quadratic		28	11.93	0.55
Cubic		28	8.87	0.50
Error (b)	960		8.93	0.49
Total	1919			
c.v. (%)			6.62	4.95

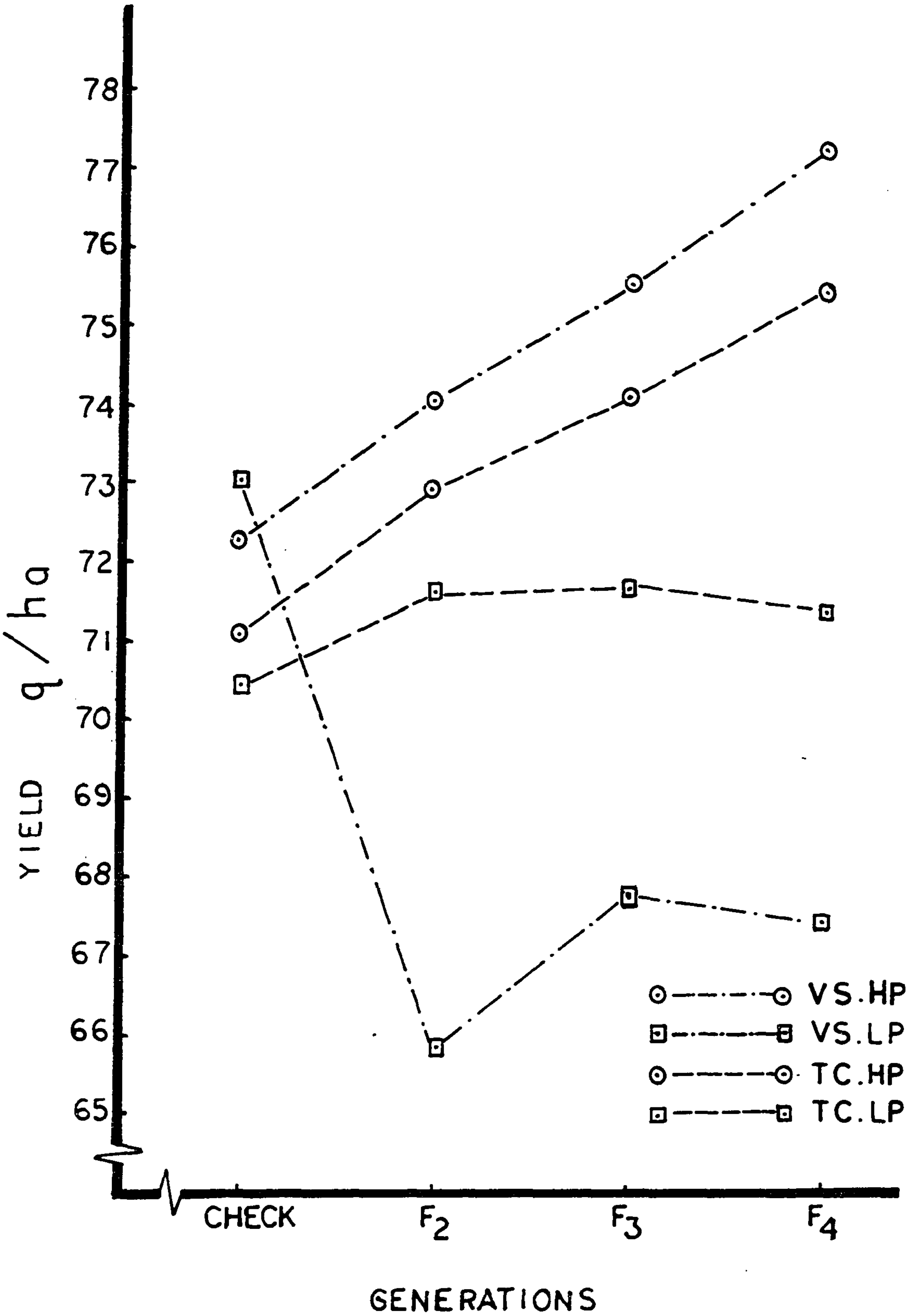
In the analyses of variance for yield (Table 39), the parts dealing with families, environments x families, generations and environments x generations are of minor interest in this study. Highly significant differences among families were obtained, as was expected because of the materials selected. Selections in groups 1 and 3 were chosen because of high testcross yields and in groups 2 and 4 because of low testcross yields, as reported by Russell and Teich (1967). The testcrosses of the F_4 generations in the present study have given yields as expected, although entry 18 in group 4 is slightly higher relative to other entries of this group (compare in Tables 2 and 39). Differences among environments were highly significant, but the interaction of environments x families was significant at only the five percent level. On the average over all families, the increase in yield from the check to F_4 testcrosses was 0.90 q/ha, which was not significant.

The part of major interest is the interaction of generations x families and the orthogonal comparisons in this interaction. Groups 1 and 3, and all testcrosses in these groups, had positive, linear regression coefficients, mainly because of the increased yields of the F_4 testcrosses as compared with the testcross of the check or source population. Group 2, and all testcrosses in this group, had negative, linear regression coefficients because of a lower yield of the F_4 testcrosses as compared with the check. Group 4 had a low, positive, linear regression coefficient; three testcrosses in this group had positive, linear regression values and two had negative, linear regression coefficients.

Graphs in Figure 7 show the generation yields of the four groups of testcrosses. Progress from selection differed between groups 1 and 2, the visually selected lines, and groups 3 and 4, the testcross selected lines ($p < 0.01$), mainly because of the great difference for group 2. The mean testcross yield of the F_2 generation in group 2 was much lower than the check, but some progress was made in the F_3 and this was maintained in the F_4. Groups 3 and 4 differed significantly over generations ($p < 0.01$ for the linear portion of variation) because group 4 showed no progress from selection in the F_3 and F_4 generations. Groups 1 and 3 showed similar progress from selection in all generations and differed by only 1.1 q/ha in mean yield for the four generations. Among the selections in groups 1 and 3 there was no significant interaction with generations, whereas in groups 2 and 4, among selections x generations were highly significant.

The second order interaction, environments x generations x families, was highly significant, mainly because of the orthogonal comparisons involving groups 1 vs 2, and among selections in groups 2 and 3. The

Figure 7. Mean testcross yields for four groups of selected families, five families per group and four generations per family, data averaged over eight environments



YIELD q/ha
78
77
76
75
74
73
72
71
70
69
68
67
66
65
CHECK
F2
F3
F4
GENERATIONS
VS.HP
VS.LP
TC.HP
TC.LP

interaction, generation x among testcrosses in group 3, was not significant, but the second order interaction, environments x generations x among testcrosses in group 3, was highly significant. The yield performances of testcrosses of the four generations for the selections in group 3, Table 39, were relatively consistent in the average over eight environments, but there were significant differences among the environments.

It is obvious from the graphs in Figure 7 that the final selections in groups 2 and 4 had low testcross performance in this study, as well as in the Russell and Teich (1967) study, because they were below groups 1 and 3 in the initial selected generation, the F_2. Groups 1 and 3 had continuous progress in selection in the three segregating generations. By contrast, group 4 showed relatively little progress from selection in any generation; group 2 had good progress from F_2 to F_3 but no further progress from F_3 to F_4. Evidently in groups 1 and 3 the F_3 and F_4 progenies were segregating at loci affecting combining ability and selection for the more favorable alleles was effective. In group 4, except entry 18, either there was less segregation at loci affecting yield than in groups 1 and 3 or else the method of selection was not effective in selecting the more favorable alleles. Selections in group 2 had fewer favorable elleles initially; some segregation permitted progress in F_3 but progress could not be made in the F_4 because of few heterozygous loci or inability of the selection method to identify the better alleles.

Mean moisture data for the testcrosses, averaged over all eight environments, are presented in Table 40. The combined analyses of variance, with appropriate orthogonal comparisons, are given in Table 41.

Moisture data for the individual locations and the analyses of variance are given in Tables 85 and 86, respectively, of the Appendix.

The error mean squares were low (Table 41), thus relatively small moisture differences were significant. Differences in family means were highly significant; also, differences between groups 1 and 2 and among selections in all groups were highly significant. Differences among generations, averaged over all families, were not significant.

In the first order interaction, generations x families, most orthogonal comparisons had significant, or highly significant, F tests. In a comparison of the yield and moisture data in Tables 39 and 40, however, there does not appear a close relationship between the two characters. Group 1 showed the greatest increase of moisture in the generations after the check, but two selections had positive, linear regression coefficients and three had negative values; all selections in this group had positive, linear regression coefficients for yield over generations. Also, all selections in group 3 had positive, linear regression coefficients for yield, but only two of these selections had positive, linear regression coefficients for moisture. Entry 18 in group 4 had a high, positive, linear regression coefficient for yield but a negative, linear regression coefficient for moisture. The methods of selection, visual vs testcross, had no significant difference in change of maturity in successive generations. Evidently, where progress in selection for yield was obtained, it did not occur because of later maturity.

The selections in groups 1 and 2 can be subdivided on the basis of whether they were developed in high or low stand densities in the breeding nurseries. There are four selections in the high-density group and six selections in the low-density group. Also, the selections in groups 3 and 4 can be subdivided on the basis of whether the testcrosses in the successive generations of development were evaluated at high or low stand densities. There are four selections in the high-density group and six selections in the low-density group. Mean yields of the four generations for these groups and the combined analyses of variance over eight environments are presented in Tables 42 and 43, respectively. Graphs of the yields of the four groups in each generation are shown in Figure 8.

Table 42. Mean yields for four groups of testcrosses, based on breeding method to develop the inbred lines, data averaged for eight environments

Groups[a]	Yield in q/ha				Regression coefficients	
	Ch	F_2[b]	F_3[b]	F_4[b]	R_ℓ	R_q
1 (VS.HS)	72.5	73.4	75.2	74.6	0.405	-0.375
2 (VS.LS)	72.8	67.6	69.3	70.0	-0.343	1.463
Mean (VS)	72.7	70.5	72.3	72.3	0.031	0.544
3 (TC.HS)	71.4	73.5	72.7	73.3	0.246	-0.370
4 (TC.LS)	70.3	71.4	73.0	73.5	0.559	-0.179
Mean (TC)	70.9	72.5	72.9	73.4	0.403	-0.275

[a]Entries representing each group are as follows:
group 1, entries 03, 04, 05, and 10
group 2, entries 01, 02, 06, 07, 08, and 09
group 3, entries 14, 15, 19, and 20
group 4, entries 11, 12, 13, 16, 17, and 18.

[b]Generations.

Table 43. Analyses of variance of yield and moisture for testcrosses of four generations of 20 selected families evaluated in eight environments

Source of variations	Degrees of freedom		Mean squares Yield	Mean squares Moisture
Environments	7		4132.05**	699.93**
Reps/environments	16		122.81**	2.29**
Families[a]	19		245.95**	39.77**
(1&2) vs (3&4)		1	103.93	3.11
1 vs 2		1	1226.88**	12.27**
3 vs 4		1	38.39	80.57**
Among 1		3	52.52	29.76**
Among 2		5	478.52**	59.95**
Among 3		3	125.36**	76.41**
Among 4		5	66.92	8.29**
Environments x families	133		30.00*	1.18**
Environments x {(1&2) vs (3&4)}		7	37.97	0.28
Environments x (1 vs 2)		7	68.97**	1.11
Environments x (3 vs 4)		7	2.20	1.12
Environments x among 1		21	38.15*	0.98
Environments x among 2		35	25.35	1.11*
Environments x among 3		21	21.58	1.34*
Environments x among 4		35	30.98	1.48**
Error (a)	304		21.90	0.70
Generations	3		69.56	0.52
Linear		1	120.71	0.02
Quadratic		1	35.30	1.54
Cubic		1	52.66	0.01
Environments x generations	21		29.98**	0.52
Linear		7	66.22**	1.18*
Quadratic		7	14.98	0.19
Cubic		7	8.73	0.19
Families x generations	57		54.89**	5.17**
{(1&2) vs (3&4)} x generations		3	140.04**	0.83
Linear		1	178.09**	0.10
Quadratic		1	157.11**	2.33*
Cubic		1	84.92*	0.06

[a]Orthogonal comparisons based on breeding groups.

Table 43 (Continued)

Source of variations	Degrees of freedom		Mean squares Yield	Mean squares Moisture
(1 vs 2) x generations	3		164.85**	0.93
Linear		1	214.32**	0.16
Quadratic		1	260.63**	2.59*
Cubic		1	19.60	0.04
(3 vs 4) x generations	3		23.77	8.56
Linear		1	36.13	23.65**
Quadratic		1	2.91	0.02
Cubic		1	32.28	2.12*
Among 1 x generations	9		45.17**	4.13**
Linear		3	91.83**	9.19**
Quadratic		3	16.67	1.29*
Cubic		3	46.07	4.31**
Among 2 x generations	15		71.03**	8.22**
Linear		5	111.68**	17.35**
Quadratic		5	84.66**	4.39**
Cubic		5	17.02	2.92**
Among 3 x generations	9		44.18**	6.19**
Linear		3	88.56**	11.21**
Quadratic		3	21.01	2.21**
Cubic		3	22.97	5.16**
Among 4 x generations	15		14.38	2.68**
Linear		5	9.19	3.76**
Quadratic		5	25.80	2.66**
Cubic		5	8.17	1.65*
Environments x families x generations	399		13.30**	0.57*
Env x {(1&2) vs (3&4)} x generations	21		13.45	0.33
Linear		7	10.76	0.44
Quadratic		7	13.98	0.24
Cubic		7	15.61	0.31
Env x (1 vs 2) x generations	21		16.31*	0.90*
Linear		7	16.53	0.72
Quadratic		7	15.45	0.48
Cubic		7	16.97	1.48**
Env x (3 vs 4) x generations	21		5.61	0.67
Linear		7	5.90	1.40**
Quadratic		7	2.23	0.20
Cubic		7	9.14	0.40
Env x among 1 x generations	63		10.14	0.38
Linear		21	9.12	0.42
Quadratic		21	12.87	0.24
Cubic		21	8.43	0.49
Env x among 2 x generations	105		14.90**	0.66*
Linear		35	16.35**	0.86*
Quadratic		35	18.09**	0.57
Cubic		35	10.28	0.54

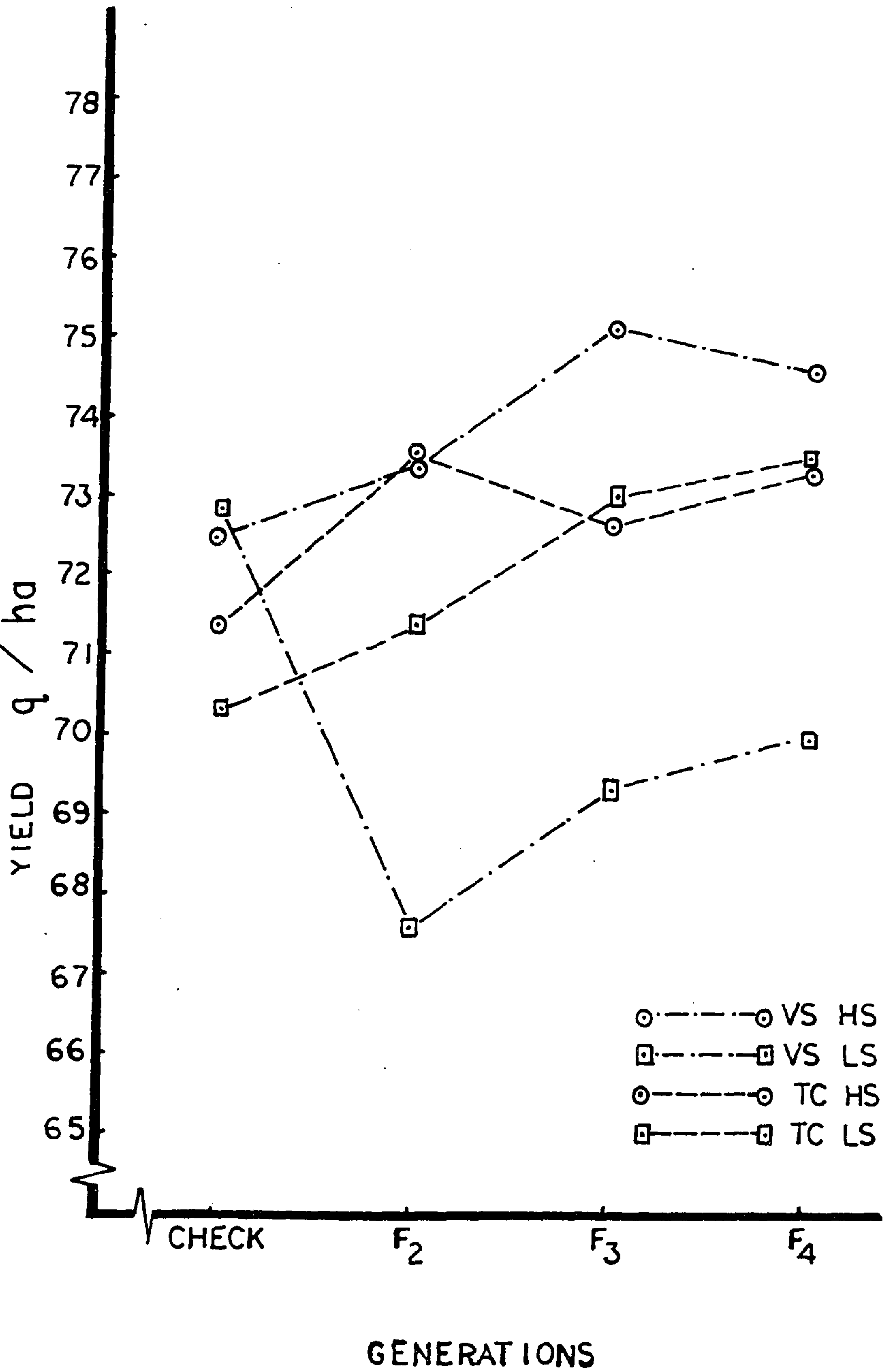
Table 43 (Continued)

Source of variations		Degrees of freedom		Mean squares Yield	Mean squares Moisture
Env x among 3 x generations		63		13.11*	0.74**
	Linear		21	17.09**	0.79*
	Quadratic		21	12.40	0.72*
	Cubic		21	9.85	0.70
Env x among 4 x generations		105		12.89**	0.45
	Linear		35	15.51**	0.65
	Quadratic		35	10.98	0.42
	Cubic		35	12.17	0.30
Error (b)		960		8.93	0.49
Total		1919			
c.v. (%)				6.62	4.95

Only group 2, whose selections were developed on the basis of inbred appearance at a low stand density, had a negative, linear regression value for generations (Table 42 and Figure 8). The interaction, generations-linear x (1 vs 2), was highly significant (Table 43). The negative, linear regression for group 2 occurred because of the high value of the check. Actually, the gain from selection in the generations after the F_2 was as great in group 2 as in any other group. Group 3 showed an excellent improvement in the first generation of selection but had no further gain in subsequent generations.

Differences among lines for gain from selection in three generations were highly significant in groups 1, 2, and 3. The lines in group 4, selected on the basis of testcross performance in low stand density, did not differ significantly in progress from selection in the three generations. In the other three groups, some lines had positive, linear regression coefficients and some had negative, linear regression

Figure 8. Mean testcross yields for 20 selected families in four breeding groups, four generations per family, data averaged over eight environments



YIELD q/ha
78
77
76
75
74
73
72
71
70
69
68
67
66
65
VS HS
VS LS
TC HS
TC LS
CHECK
F_2
F_3
F_4
GENERATIONS

coefficients (Table 89 of the Appendix). In group 2, all lines showed a positive gain from F_2 to F_4 but only two of the six lines had a positive gain relative to the check.

The explanation for the group differences presented graphically in Figure 8, particularly for group 2, may be simply a reflection of the materials selected for the study. Group 2 contains a disproportionate number of lines selected originally because of a low testcross performance. If in each group one looks at only the high performance testcross, there is a distinct change.

Table 44. Mean yields for testcrosses of four generations in families with high performance testcross, in each of four groups averaged over eight environments

Groups	Yield in q/ha				Regression coefficient
	Ch	F_2[a]	F_3[a]	F_4[a]	R_ℓ
1	70.7	74.6	75.7	76.0	0.698
2	73.7	73.4	75.7	76.5	0.595
3	71.0	74.6	75.3	76.4	0.855
4	70.9	71.2	73.2	74.6	0.660

[a]Generations.

The differences among the groups are small and probably not significant. Progress has been made in all groups in all generations of selection except the first generation, F_2, for group 2 (Table 44). These lines represent the elite among the greater number of lines evaluated by Russell and Teich (1967). These lines were elite because they were at least equal to or better than the check at the F_2 and effective selection in subsequent generations improved their combining ability for yield. Such comparison must be made with caution, however, because there are so few selections in any one group.

For grain moisture, generations x families was highly significant (Table 43). Generations x (3 vs 4) had a highly significant difference for the linear trend, positive in group 3 and negative in group 4 (Table 90 of the Appendix). Tables 87 and 88 of the Appendix present the individual locations analyses of variance for yield and moisture, respectively, for the breeding classification. Differences among lines for the linear regression coefficient were highly significant among lines in all groups. As pointed out previously, however, there appears to be little relationship between change of maturity and change in yield.

V. DISCUSSION

A. Part a)

Many studies have been done that show differential effects of plant stand densities on hybrid maize yield performance. Relatively less information has been published, however, to show the effects of varying plant densities to yield components, except for barrenness or number of ears produced per plant. The objective of the first part of this research was to determine for 20 selected inbred lines the relationship of important plant and ear characters to grain yield and to determine the effects to this relationship when plant stand densities are varied. Also included was a study of the relationship of the first and second cob growth of the inbreds to the testcross yields. Since the variation among the inbred testcrosses for relative yield performance at the three stand densities was appreciable, linear regression values ranged from -2.30 to 11.90 for the two extremes, one should expect the effect of densities to the relationship of plant and ear characters with yield to be revealed rather well. Actually, with the removal of the lowest yielding environment, Ankeny in 1968, the maximum difference between environments averaged for all testcrosses and densities was 13.4 q/ha and between densities averaged over all testcrosses and environments was 13.0 q/ha.

The 20 inbred lines used in this research were selected on the basis of their testcross performance in the study of Russell and Teich (1967). They were in two groups, a high performance and a low performance group, on the basis of their average yields and relative performances with increasing stand densities. It was interesting to note the similarities of relative performance of the two groups between the two studies. Also, entries 10 and 16 were highest and lowest, respectively, in both studies. The main difference was that only entry 16 in this study had a negative, linear regression value for response to stand densities, whereas in the Russell and Teich (1967) study all entries in the LP group and two entries in the HP group had negative regression values. Probably the greater positive responses to increased stand densities in this study occurred because of the higher yield levels that were obtained.

Phenotypic and genotypic correlations were obtained between testcross yields and all plant and ear characters. Genotypic correlations may be caused by two mechanisms, pleiotropy and linkage. Pleiotropy is the property of the gene, or groups of genes, to affect two or more characters. If there is segregation at the loci where these genes are located, the result is simultaneous variation in the characters affected. The correlation observed is the net effect of all segregating genes that affect both characters under study. Some genes may increase the magnitude of both characters, thus giving positive correlation, whereas other genes may increase one character and decrease the second to give a negative correlation. If both types of action are occurring for two characters, the net result may be no detectable correlation. Linkage may be an important cause of correlation, particularly noticeable in populations derived from crosses between strains with very divergent characters. Random mating in the population will lead to genetic equilibrium and decreased correlation.

Genotypic and phenotypic correlations calculated from the covariance analyses show the relationship between yield and the plant and ear characters, averaged over all plant stand densities and environments. The greatest correlation was for number of ears per plant and yield of the testcrosses. Number of ears per plant was mainly a measure of barrenness because relatively few plants had second ears, even at the lowest stand density. Probably delayed silk emergence relative to pollen shedding enhanced barrenness. Woolley, Baracco, and Russell (1962) reported that the hybrids with the longest interval between pollen shedding and silk emergence had the lowest yields at the high density, and those hybrids with the shortest interval had the highest yields. In the present study the delay in silk emergence relative to pollen shedding at the high density ranged from 0.9 to 3.0 days among testcrosees. The testcross with the least silking delay at the highest density, entry 10, had the highest average yield (91.0 q/ha), whereas the testcross with the greatest silking delay at the highest density, entry 16, had the lowest average yield (57.2 q/ha). Also, entry 10 had the highest number of ears per plant at the highest density (0.99 ears per plant) and entry 16 had the lowest number of ears per plant at the highest density (0.73 ears per plant).

Plant densities had significant, or highly significant, effects on most characters studied, and in several instances the densities x entries interactions, or some orthogonal comparison within this interaction, were significant. Usually, plant and ear heights of testcrosses increased as plant densities were increased, and ear characters and yield per plant decreased in magnitude. Consequently, the relationships among the characters studied would be expected to vary for the three stand densities.

The importance of plant density on the relationship among plant and ear characters and of these characters to yield was clearly demonstrated in this study. A comparison of the phenotypic correlation coefficients calculated at the three stand densities showed that r-values for only the data averaged over all densities may not give the best information. In general, as the plant density increased the magnitude of the correlations and number of significant correlations increased, indicating more dependent relationships among plant and ear characters and of yield with these characters at the level of greater environmental stress to the individual plant. These results suggest the question of whether or not the correlation of inbred plant and ear characters with the yield performance of the inbred in hybrid combinations would likewise increase as the level of the environmental stress to the individual plant is increased.

Weight per 300 seeds was the only ear or seed character that did not have a significant correlation with yield at any stand density. The only correlations of importance for seed size were the highly significant, negative values with number of seeds per plant at all stand densities. All other ear and seed characters had significant, or highly significant, correlations with yield at one or more stand densities. The phenotypic correlation between testcross yield and number of ears per plant was highly significant at the highest plant density but not at the two lower densities. This result should have been expected because barrenness was negligible at the low and medium stand densities. Ear length, kernel depth, and number of seeds per plant also had highly significant correlations with yield at the highest stand density but r-values at the other two densities were not significant. Ear diameter and shelling percent had highly significant correlations with yield at the highest stand density, significant correlations with yield at the intermediate density, but nonsignificant correlations at the lowest density.

Generally, correlations among the yield components and of yield components with yield that would be most useful to the maize breeders for prediction purposes were obtained at the highest stand density. Since the most important yield component appeared to be ears per plant, the results emphasize that, if the greatest relationship of yield components with yield is to be realized, the individual plant must be at a level of stress where some barrenness will occur. Unfortunately, the optimum density that will give the best stress condition will vary among environments and the breeder will not know at planting time what stand density will be required. Consequently, the breeder could expect to obtain more information per location if two or three densities are used. The testcross that maintains a high level of ears per plant, or resists barrenness, as plant stand densities are increased will have increased yields because the decrease in yield per plant is more than offset by the number of ears per unit area. This conclusion is in general agreement with the results of Dungan, Lang and Pendleton (1958), Stringfield (1962), Zieserl, Rivenbark, and Hageman (1963), and Rossman and Cook (1966).

Data on dates of pollen shed and silk emergence were taken on only the Ames tests; consequently, relationships of these characters with all other characters across plant densities were not evaluated. The interval between the two events was increased at the highest density because of delayed silk emergence and not because of any effect to time of pollen shedding. The extent of delay in silk emergence varied among testcrosses, but the variation was not great enough to give a significant density x entry interaction. Previous studies relating to silking and shedding dates indicate inconsistent results. Wofford, Horner and McCloud (1956) reported that plant density increases did not affect silking date, whereas Woolley, Baracco, and Russell (1962) and Rossman and Cook (1966) obtained delays of one to five days because of plant density increases. Kahnke and Miles (1951) reported a silking delay of one day for each 3,500 to 4,000 plants per acre increase. Shubeck and Caldwell (1955) reported that an increase in plant density from 3,556 to 17,780 plants per acre caused five days delay in silk emergence. Woolley, Baracco, and Russell (1962) noted an increase in the anthesis-silking interval of 1.2 days with increases from 16,000 to 24,000 plants per acre in a favorable season and 4.4 days in an unfavorable season.

There were no significant correlations between yield and either date pollen shed or date silk emergence at any of the three stand densities. Probably this failure to obtain significant correlations occurred because of a relatively narrow range among the testcrosses for dates of pollen shed and silk emergence. The correlation between yield and the silking-pollen shed interval was highly significant and negative at the highest stand density, but not significant at the two lower densities. Presumably, as the interval between pollen shedding and silk emergence was increased, barrenness was increased, or number of ears per plant decreased. Probably the relationship between silk emergence delay and the amount of barrenness is much greater than could be observed in a study of several hybrids because in a pure stand of one testcross the period of available pollen would be much shorter than in an area where several hybrids are grown. The importance of selecting for materials that have simultaneous dates of pollen shedding and silk emergence under stress conditions is obvious.

Plant and ear heights of the testcrosses were significantly correlated as should be expected since both characters are determined by the number and length of the internodes. The correlation was affected relatively little by plant stand density, although it was slightly higher at the lowest density. Since approximately 50 to 65 percent of the variation in ear heights of the testcrosses was accounted for by the variation in plant heights, it is obvious that selection for plant height will have considerable effect on ear height. Both characters were positively and significantly correlated with testcross yields indicating that the taller genotypes were higher yielding. Stand densities, however, had only a small effect on these correlations, the values being highest at the highest density. The relationship of either plant or ear heights with any of the other characters studied in all environments was of no importance.

Russell and Teich (1967) hypothesized that materials selected for high performance in high plant densities would have superior yield performance in both low and high densities, but materials selected in low plant densities would not necessarily have superior yield performance in high densities. The results from the present study support their hypothesis, but caution must be used in interpreting the data because of the relatively few lines evaluated and because they are highly selected samples.

The development of maize inbred lines is still a major part of a practical maize breeding program. For many years when the product used by the farmers was the double cross hybrid probably the most emphasis in the inbred development was its performance in hybrid combinations. Now, however, with the much greater use of single cross hybrids, emphasis is much increased on the development of inbred lines that produce a high quantity of good quality seed. To the extent that there is a positive correlation between yield of the inbred *per se* and yield of the inbred in hybrid combinations, emphasis on high yielding inbreds will increase yield potential of hybrids. Russell and Teich (1967) showed that selection of inbred lines in high stand densities gave significantly higher yielding strains than when selected in low stand densities. Furthermore, the lines selected in the high stand density gave higher hybrid yields. The relationships among plant and ear characters of testcrosses at different stand densities in the present study suggest that correlations of inbred characters with hybrid yields, if data are collected in a high yield environment with considerable stress at the individual plant level, may be better than observed in some earlier studies, Jenkins (1929) and Hayes and Johnson (1939).

The study of Russell and Teich (1967) showed a positive relationship for rate of growth of the second cob of the inbred with its hybrid yield performance. Inbreds that had strong second cob development had less barrenness at high stand densities. If this resistance to barrenness in the inbred is highly heritable in the hybrid progeny, selection for second cob growth may be worthwhile. Growth of the second cob may be simply an expression of a vigor character that is positively correlated with hybrid yield performance.

Cob growth data obtained for the inbred lines in this study showed that the inbreds developed by visual selection had significantly greater second cob length than the lines selected at a low density density, although the difference was not significant. These data are in agreement with the results obtained by Russell and Teich (1967). If good second cob length is a desirable feature in an inbred line, these results indicate that it can be achieved by developing the inbred at a stand density that gives considerable stress to the individual plant. Correlations of growth rates for both cobs with testcross yields were found to be highly significant, but cob lengths were not correlated with hybrid yields. However, the phenotypic correlations between final cob length and rate of cob growth were highly significant, suggesting that selecting for final cob length at silk emergence may be just as valuable as selection based on growth rate. Cob length at silk emergence is much easier to obtain and would permit measurements of more plants, thus giving greater precision to the data.

It may be concluded from this research that the difference in performance of the HP and LP groups was determined by all yield components studied in the testcrosses except weight per 300 kernels. Number of ears per plant was of greatest importance, although ear diameter was nearly as important. Yield differences between the two groups were only 1.1 q/ha at the lowest stand density, 2.2 q/ha at the intermediate density, and 7.8 q/ha at the highest density. In the HP group all entries had their highest yields at the highest stand density. Relationships of the yield components to yield were greatest at the highest density. Thus, if the potential development for yield components is different among hybrids, the differential expression will be best in a high yield environment where there is considerable stress to the individual plant. In this study, cob length of the inbred did not show a significant relationship with hybrid yield performance. However, the range in values for cob length was not great in this selected sample, and certainly was much less than the difference between M14 and C103 for second cob length. These cob length data were obtained in a low stand density in which there would be a low stress on the individual plant. If the data were taken in a higher stand density, probably greater differences would occur among inbreds for amount of second cob growth.

B. Part b)

The materials selected for this part of the thesis were chosen because the final generation tested by Russell and Teich (1967) had either a high or low testcross yield performance. Consequently, evaluating testcrosses of the selected progenies in three successive generations, F_2 to F_4, should show if a testcross was high or low yielding because of the genotype of the plant chosen in the first segregating generation, F_2, or because of genetic segregation and selection in the F_3 and F_4 generations. Furthermore, since these materials were developed on the basis of visual discrimination or testcross performance, the study should suggest which selection method effected greatest genetic change.

The success of a maize breeding program is determined by the hybrid performance of the material under selection. When combining ability in hybrid combinations is the objective, breeders usually proceed by testing for general combining ability in the earlier generations and then follow by evaluating for specific combining ability. General combining ability tests may start as early as the first segregating generation, but specific combining ability tests usually are delayed at least to the fourth or fifth generations of selfing. Because testcross evaluation is costly, it usually limits the size of the population that may be tested. Consequently breeders frequently use visual selection among and within progeny rows in the early inbreeding generations and test later when many of the selections have been eliminated.

The effectiveness of visual selection for combining ability during the inbreeding generations has been a subject of disagreement among breeders. Jenkins (1929) and Sprague and Miller (1952) denied any influence of visual selection during inbreeding on the general combining ability of the selections. On the other hand, Hayes and Johnson (1939), Osler, Wellhausen and Palacios (1958), and Russell and Teich (1967) supported the efficacy of visual selection on combining ability. The number of generations that selection in progeny rows may be profitable cannot be specified, but progress will diminish quickly because of a rapid approach to homozygosity in individual progenies. Russell and Teich (1967) concluded that visual evaluation of inbred line performance in dense plant stands was at least as effective as selection by extensive testcrosses, and far more efficient. They suggested that further evaluation of breeding methods may find that the effort expended for measurement of general combining ability by topcross tests may be partly or completely replaced by inbred line performance, and at a much lower cost.

Selections 1 to 10 (Table 39) were selected by visual discrimination of the inbred progenies and 11 to 20 by testcross performance. In the present study families in groups 1 and 3 were selected because of high testcross performance and groups 2 and 4 because of low testcross performance of the final generations evaluated by Russell and Teich (1967). Group means of the F_4 testcrosses in 1 and 3 exceeded 2 and 4 and all selections in 1 and 3 exceeded all selections in 2 and 4, except for selection 18. Also, group means of the F_2 testcrosses in 1 and 3 were greater than in 2 and 4, although the differences were slightly smaller than for the F_4. Only in group 4 mean was there no gain in yield due to selection in the F_3 and F_4 generations. The high yielding selections were high because of a high yielding F_2 generation and/or because selection pressures were able to detect the higher yielding genotypes in the F_3 and F_4 generations. In groups 2 and 4 (except for selection 18), testcrosses of the F_4 generations were low because of a low yielding F_2 and because there were no loci segregating for genes affecting yield, or the methods of selection did not detect genetic differences. The genotype of the F_2 plant selection determines the ceiling for the yield potential of segregates in succeeding generations, but whether or not an increase in yield is realized by further selection depends upon the ability of the selection method to detect combining ability differences among the segregates. Two selections in group 2 had strong positive gains from the F_2 to F_4, but were still low yielding as F_4 testcrosses because of low yield level of the F_2.

Differences of the high performance groups 1 and 3 with the low performance groups 2 and 4 with respect to improvement of combining ability could be a result of the relative importance of the different types of gene action. Lonnquist and Castro (1967) indicated that there appeared to be more additive than nonadditive genetic variance for yield within lines selected as high yielding in testcross performance (similar to group 1 in this study). On the other hand, low performance S_1 lines exhibited, generally, more nonadditive genetic variance. If the families in groups 2 and 4 in this study have relatively more nonadditive than additive genetic variance, then failure to improve combining ability in successive generations of selection may be due to the decrease of the nonadditive variance.

The 20 families can be divided into four groups on the basis breeding methods used in their development (Table 17). The performance of these groups are summarized in Table 42 and are presented graphically in Figure 8. In the visually selected lines, group 1 selected in high stand densities had a positive regression value, and group 2 selected in low stand densities had a negative regression value. These regression values suggest that the effectiveness of visual selection to detect favorable genotypes in successive segregating generations was determined by the stand density. It is obvious from Figure 8, however, that group 2 was low yielding because of the low performance of the F_2 genotypes. Actually, on the basis of group means, there was more gain from F_2 to F_4 in group 2 than in group 1. In these two groups the first initial selection at the two stand levels was among and within F_3 progenies and in this generation selection at the high stand density was very effective in eliminating genotypes with a high incidence of barrenness. Selection was probably more gradual at the low stand density, thus resulting in a positive gain in the two following generations. Because of a rapid approach to homozygosity under selfing, gains due to within progeny selection would be expected to decrease rapidly after the F_3 generation.

Groups 3 and 4 were selected on the basis of testcross performance at high and low stand densities, respectively. Both groups had positive, linear regression coefficients although the value for group 4 was slightly higher than for group 3. Again, the group selected at the high density had the initial advantage because of superior F_2 genotypes, but no further gain was made in the F_3 and F_4. Groups 2 and 4 had almost identical gains in the second and third generations of selection.

Conclusions relative to the efficacy of different selection techniques should not be made on the basis of the results from this study. The 20 families are a selected set and were studied mainly to determine the basis for some having high yields and some having low yields in testcrosses of the final generations. Consequently, any trends observed relative to selection procedure may be properties of the families selected and may not have any relationship to selection techniques. Also, it must be remembered that all these lines survived all selection pressures in the original sampling of offspring from M14xC103. The information now at hand was not even estimable before the study by Russell and Teich (1967). Only by studying all lines evaluated by Russell and Teich would it be possible to have data upon which one could formulate conclusions relative to breeding procedures.

Generally, the level of grain moisture at harvest is a good maturity index when comparing among hybrids. It is significant to find that there was no obvious relationship between changes of yield in successive generations of selection and maturity. Usually, there is a positive correlation between yield and maturity but, within the maturity limits of the material used here, changes of yield in the successive generations could not be explained by changes of maturity. Consequently, within narrow limits at least, positive gain can be made for yield without sacrificing earlier maturity.

Generally, it may be concluded from this part of the present study that the testcross performance level of a line at the F_4 or F_5 will be determined in two ways: performance level of the genotype selected in the first segregating generation and the extent to which segregation in succeeding generations will permit selection of still better genotypes. The performance level of the first selection does not determine whether or not further gain will be made by selection within the progenies in succeeding generations. It should be advantageous to use whatever selection pressures are available to select the most superior genotypes in the first or second segregating generation.

VI. SUMMARY AND CONCLUSIONS

Field experiments were conducted during 1966-68 as follows:

1) For a selected group of inbred lines developed from M14 x C103, to evaluate in testcrosses of the lines the relationships of important plant and ear characters to grain yield and to determine the effects of varying plant stand densities on these relationships.

2) For the inbred lines in 1), to determine the rate of cob growth at the two top ear nodes during the period of rapid ear shoot development before silk emergence and to relate this cob development to the hybrid performance of the lines.

3) For a selected group of the M14xC103 inbred lines, to determine if the high or low testcross yield performance of the final generation evaluated by Russell and Teich (1967) was caused by the yield level of the F_2 genotype or by genetic segregation and selection in the F_3 and F_4 generations.

Experiments to study part 1) were grown in six environments, three plant stand densities in each environment. Characters evaluated were dates of pollen shed and silk emergence, silking-pollen shed interval, plant and ear heights, ear length, ear diameter, kernel depth, shelling percentage, 300-kernel weight, number of seeds per plant, and grain yield. The inbred lines used were in two groups of ten each, a high performance group and a low performance group on the basis of their average testcross yields and relative performances with increasing plant stand densities in the study of Russell and Teich (1967). The tester was WF9xI205, which was the same as used in the earlier study.

Relative yields of the testcrosses, averaged over all environments, were very similar to the earlier study. Genotypic and phenotypic correlation coefficients were calculated from the covariance analysis to show the relationship between yield and the plant and ear characters, averaged over all plant stand densities and environments. Significant, or highly significant, positive correlations were obtained between yield of the testcrosses and number of ears per plant, ear length, ear diameter, kernel depth, shelling percentage, and number of seeds per plant. Number of ears per plant, which was mainly a measure of barrenness because relatively few plants had second ears, had the highest correlation with yield. Maturity, on the basis of dates of pollen shedding and silk emergence, had no significant correlation with yield; the silk emergence-pollen shedding interval, however, had a significant, negative relationship with yield. Generally, the genotypic correlations were of greater magnitude than were the phenotypic correlations.

The phenotypic correlation coefficients calculated at each plant stand density demonstrated the importance of density on the relationships among plant and ear characters and of these characters with yield. At the low stand density, only plant and ear heights were significantly correlated with yield. At the intermediate density, ear diameter and shelling percentage, in addition to plant and ear heights, were significantly correlated with yield. At the high density, however, all characters except 300-kernel weight, silking date, and pollen shedding date were correlated significantly, or highly significantly, with yield.

Generally, as the plant stand density was increased the magnitude of the correlations increased, indicating more dependent relationships among plant and ear characters and of yield with these characters at the level of greater environmental stress to the individual plant.

Experiments to study part 2) were grown for two years at one location. These experiments included the same 20 inbreds indicated for part 1) and also M14 and C103. The plant stand density was approximately 29,000 plants per hectare. Cob length measurements for the two top ears were taken at 3-day intervals during the 15 days preceding silk emergence.

The correlation coefficients of growth rates for the two top ears with testcross yields were highly significant, but actual cob lengths at silk emergence were not correlated with hybrid yields. However, the phenotypic correlations between cob length at silk emergence and rate of cob growth were highly significant, suggesting that selecting for cob length at silk emergence may be just as valuable as selection based on growth rate, and could be done at a much lower cost.

The experiments for part 3) were grown at one plant stand density in eight environments. Twenty families were selected for this study because the final generation evaluated by Russell and Teich (1967) had either a high or low testcross yield performance. The results suggested that the testcross performance level of an inbred line at the F_4 or F_5 generation has been determined in two ways:

a) Genotype of the plant selected in the first segregating generation.

b) Genetic segregation within the offspring in succeeding generations and the extent to which selection has been able to pick the best genotypes. The performance level of the first selection does not determine whether or not further gain will be made by selection within the progenies in the succeeding generations. It should be advantageous to use whatever selection pressures are available to select the most superior genotypes in the first or second segregating generation.

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IX. APPENDIX

Table 45. Average agronomic data for 13 plant and ear characters in testcrosses of 20 selected inbred lines and three checks evaluated in three plant densities at Ames, 1966

	Low[a]	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
HP group	Yield in q/ha			No. ear/plant			Plant height (cm)			Ear height (cm)			Ear length (mm)		
01	72.8	85.2	93.0	0.96	1.00	0.94	199	205	207	85	85	87	194	181	162
02	72.5	81.6	97.8	1.00	0.98	0.94	202	197	200	80	82	86	200	186	165
03	78.4	84.8	96.0	1.00	0.94	1.00	192	191	196	79	79	85	221	190	171
04	78.1	82.8	99.6	0.98	0.98	0.96	206	201	194	90	86	90	202	191	164
05	73.2	77.9	85.2	1.00	1.00	0.96	192	193	198	82	79	81	216	196	171
06	75.3	83.7	86.4	0.94	0.94	0.86	199	201	202	97	90	93	207	191	165
07	72.8	84.4	91.8	0.98	0.98	0.92	200	198	199	84	84	88	216	202	170
08	77.2	88.5	89.4	1.00	1.00	0.92	193	196	199	88	90	94	219	209	172
09	71.3	77.5	77.5	1.00	0.98	0.94	179	176	185	75	75	75	208	195	159
10	80.6	95.0	117.4	1.00	1.00	0.98	213	213	210	93	91	92	217	201	189
$\bar{x}$	75.2	84.1	93.4	0.99	0.98	0.94	198	197	199	85	84	87	210	194	169
LP group															
11	74.7	86.5	100.7	0.96	0.94	0.96	212	195	164	83	81	86	205	197	180
12	73.8	86.9	72.1	0.98	1.00	0.92	196	191	198	85	83	85	194	185	138
13	75.6	77.5	86.4	1.00	0.98	0.92	195	193	199	83	81	86	217	190	161
14	73.5	94.6	112.7	0.96	0.94	0.94	206	203	205	90	88	87	218	218	198
15	75.6	78.3	87.0	0.98	0.96	0.92	198	196	204	87	89	94	181	173	156
16	69.1	74.6	53.1	0.92	0.96	0.60	191	187	196	75	75	81	210	196	114
17	73.5	79.1	93.0	1.00	0.98	0.92	191	193	197	79	85	87	224	202	176
18	78.4	87.7	92.4	1.00	0.96	0.90	204	203	204	91	91	97	219	198	165
19	73.8	79.5	85.8	1.00	0.90	0.84	198	200	198	84	87	86	224	202	162
20	75.3	81.6	91.8	0.96	0.98	0.90	210	211	218	92	96	98	216	193	162
$\bar{x}$	74.3	82.6	87.5	0.98	0.96	0.88	200	197	198	85	86	89	211	195	161
Checks															
21	79.0	79.1	88.2	1.00	0.96	0.94	195	191	192	82	85	86	214	175	162
22	70.1	73.0	88.8	0.96	0.88	0.78	213	207	217	91	90	97	200	180	149
23	74.1	68.1	80.5	0.98	0.92	0.88	203	205	201	90	91	89	210	176	151

[a]Plant densities.

Table 45 (Continued)

	Low[a]	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
HP group	Ear diameter (mm)			Shelling percent			Kernel depth (mm)			300-kernel wt(g)			No. seed/plant		
01	49	48	42	84.1	83.6	85.0	21	21	18	94.7	94.7	85.4	747	698	542
02	52	48	46	82.5	84.4	85.5	22	20	20	91.9	88.4	83.5	772	676	589
03	51	47	46	83.4	84.3	84.7	21	18	20	88.4	83.8	77.6	859	745	621
04	51	48	44	83.8	84.8	84.8	22	18	18	82.8	75.7	72.2	911	811	690
05	49	47	42	84.2	84.3	83.7	20	19	17	83.2	70.6	74.2	855	806	582
06	49	46	40	84.8	85.2	85.2	21	19	17	88.6	84.0	79.2	824	730	551
07	49	48	43	84.5	84.6	85.0	21	21	17	84.8	80.2	73.6	830	777	628
08	50	48	43	81.9	83.8	83.2	20	19	18	84.7	76.0	71.2	882	855	633
09	50	46	41	83.6	84.2	83.8	21	19	17	88.8	78.3	78.9	777	725	494
10	54	51	45	83.8	84.2	85.6	23	23	18	99.8	94.4	85.3	784	748	691
$\bar{x}$	50	48	43	83.7	84.3	84.6	20	20	18	88.8	82.6	78.1	824	757	602
LP group															
11	48	45	44	84.0	83.1	83.2	18	17	17	83.3	76.6	68.4	867	825	739
12	50	50	41	83.8	84.2	81.9	22	22	17	90.6	90.2	87.4	795	707	412
13	50	47	42	80.9	80.2	81.0	20	19	18	88.1	81.4	78.7	828	696	554
14	47	47	44	82.7	84.4	84.0	18	20	18	95.3	89.5	84.7	745	777	657
15	51	48	47	83.4	83.6	84.7	21	20	21	83.4	78.4	74.4	879	731	607
16	45	44	25	83.1	83.2	82.2	18	17	11	92.8	86.8	76.9	752	633	352
17	47	45	40	81.9	83.7	84.0	19	18	18	92.9	80.5	77.7	763	723	499
18	49	46	40	82.9	83.5	82.9	20	19	16	90.5	86.1	78.3	840	745	621
19	47	43	37	82.6	82.0	82.9	18	18	16	97.7	91.4	88.4	729	637	520
20	48	47	41	82.7	82.7	83.0	22	19	17	95.4	91.5	85.4	766	654	538
$\bar{x}$	48	46	40	82.8	83.1	83.0	20	19	17	91.0	85.2	80.0	796	713	550
Checks															
21	50	47	43	84.5	84.5	84.7	21	20	17	86.8	81.5	71.8	883	709	613
22	47	41	37	81.8	82.4	82.1	17	18	15	92.4	84.7	83.1	711	635	533
23	49	44	39	82.8	81.6	82.9	20	17	15	86.8	84.0	78.6	826	597	514

Table 45 (Continued)

	Low[a]	Med	High	Low	Med	High	Low	Med	High
HP group	Silking date[b]			Shedding date[b]			(Silking date-shedding date) +10		
01	24.2	24.6	24.4	23.2	22.6	21.6	11.0	12.0	12.8
02	24.6	24.4	23.8	24.0	23.4	22.2	10.6	11.0	11.8
03	24.4	25.2	25.2	23.6	24.4	22.8	10.8	10.8	12.4
04	25.6	26.2	26.4	25.2	24.8	24.8	10.4	11.4	11.6
05	23.6	24.4	24.6	21.4	21.8	21.4	12.2	12.6	13.2
06	25.0	24.6	26.6	24.2	23.0	24.2	10.8	11.6	12.4
07	25.4	25.0	25.4	23.2	22.6	22.2	12.2	12.4	13.2
08	25.2	25.2	26.2	23.8	23.2	23.8	11.4	12.0	12.4
09	22.2	22.6	23.0	21.8	21.4	21.2	10.4	11.2	11.8
10	24.0	25.6	25.0	24.2	25.0	24.0	9.8	10.6	11.0
$\bar{x}$	24.4	24.8	25.1	23.5	23.2	22.8	11.0	11.6	12.3
LP group									
11	25.2	25.8	25.8	24.4	24.0	23.4	10.8	11.8	12.4
12	24.2	24.0	24.6	22.2	21.4	23.0	12.0	12.6	11.6
13	24.0	23.2	26.0	21.8	23.2	21.8	12.2	12.0	14.2
14	26.2	25.2	26.8	25.8	24.0	25.0	10.4	11.2	11.8
15	26.4	26.6	27.2	25.0	24.4	24.6	11.4	12.2	12.6
16	24.8	25.2	27.0	21.4	22.0	24.2	13.4	13.2	12.6
17	25.6	25.6	25.4	24.6	24.2	23.0	11.0	11.4	12.4
18	24.2	26.2	26.8	23.4	24.6	24.2	10.8	11.6	12.6
19	23.8	25.0	26.2	21.2	22.0	22.6	12.6	13.0	13.6
20	25.6	26.4	27.4	24.4	24.4	25.4	11.2	12.0	12.0
$\bar{x}$	25.0	25.3	26.3	23.4	23.4	23.7	11.6	12.1	12.6
Checks									
21	24.2	24.8	24.8	23.4	23.6	23.4	10.4	11.2	11.4
22	26.4	27.6	27.8	25.6	25.0	24.8	10.8	12.6	13.0
23	24.6	24.8	26.4	23.6	24.4	23.8	11.0	10.4	12.6

[b]Coded.

Table 46. Average agronomic data for 10 plant and ear characters in testcrosses of 20 selected inbred lines and three checks evaluated in three plant densities at Kanawha, 1967

	Low[a]	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
HP group	Yield in q/ha			No. ear/plant			Plant height (cm)			Ear height (cm)			Ear length (mm)		
01	65.7	75.9	85.8	0.98	0.96	0.98	208	199	202	90	88	95	185	176	155
02	61.4	71.0	88.2	1.00	1.00	0.96	205	197	211	92	85	93	183	176	154
03	63.2	75.0	82.3	0.98	0.96	0.90	212	201	197	95	87	87	188	176	149
04	61.7	71.4	83.5	0.94	1.00	0.94	208	202	201	91	91	91	186	176	152
05	63.9	71.4	83.5	1.00	1.00	0.98	205	204	211	95	93	97	196	181	164
06	60.1	73.4	68.0	0.96	0.98	0.88	212	211	208	100	89	97	179	173	133
07	64.5	71.0	87.0	0.98	0.96	1.02	210	202	204	96	90	99	202	185	169
08	60.4	76.3	75.1	1.00	1.00	0.96	202	206	199	93	95	88	205	197	166
09	64.5	77.9	84.1	0.98	1.00	0.94	206	197	195	93	86	87	200	188	158
10	58.9	75.0	96.0	0.94	1.00	1.00	212	222	209	95	104	96	185	181	171
$\bar{x}$	62.4	73.8	83.4	0.97	0.99	0.96	208	204	204	94	91	93	191	181	157
LP group															
11	56.1	69.0	68.6	0.90	0.94	0.88	206	213	195	95	95	86	178	179	147
12	62.9	75.0	72.7	0.98	0.98	0.88	203	199	201	90	89	91	182	173	129
13	60.8	73.4	68.6	0.96	0.98	0.80	198	211	208	89	93	92	194	179	133
14	59.8	69.0	61.4	1.00	0.96	0.78	212	214	190	94	97	90	203	189	135
15	55.8	71.4	60.2	0.94	0.98	0.82	200	213	195	89	96	91	170	167	119
16	48.4	64.0	42.3	0.88	0.94	0.54	203	200	198	89	87	86	176	186	94
17	58.3	71.8	68.6	0.94	1.00	0.86	206	200	198	93	88	91	203	202	157
18	63.9	71.0	72.7	0.96	0.94	0.90	208	209	203	95	94	93	196	172	157
19	66.0	76.7	73.3	0.98	0.96	0.86	199	205	210	90	94	95	214	202	163
20	60.8	72.6	76.3	0.94	0.96	0.96	205	212	204	91	92	90	189	179	157
$\bar{x}$	59.3	71.4	66.5	0.95	0.96	0.83	204	208	200	92	93	91	191	183	139
Checks															
21	63.9	75.0	73.9	0.98	0.98	0.88	192	203	191	86	91	86	186	175	130
22	43.4	63.2	56.0	0.78	0.96	0.78	215	204	202	96	92	92	147	184	139
23	65.4	71.4	70.9	1.02	0.96	0.86	211	208	205	94	94	98	200	175	139

[a]Plant densities.

Table 46 (Continued)

	Low[a]	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
HP group	Ear diameter (mm)			Shelling percent			Kernel depth (mm)			300-kernel wt (g)			No. seed/plant		
01	50	48	46	81.4	80.8	80.7	19	19	17	90.5	84.1	77.7	704	663	552
02	50	49	47	80.3	80.1	81.6	19	19	18	92.0	86.7	84.4	648	603	525
03	50	49	43	80.9	81.8	79.4	18	18	16	79.7	76.6	71.2	764	720	571
04	47	48	43	81.5	81.2	81.6	18	17	15	79.9	76.0	66.3	742	689	628
05	50	48	46	81.4	81.0	81.7	18	17	17	78.9	74.3	65.9	783	709	637
06	48	47	39	80.7	80.5	78.7	20	19	14	81.5	80.4	71.5	713	673	470
07	49	46	45	81.3	81.7	80.9	19	17	18	79.6	73.1	66.5	782	716	648
08	48	48	43	78.9	78.8	77.5	17	18	15	79.6	76.4	60.5	734	736	622
09	47	48	44	81.8	81.8	81.7	20	18	17	80.5	79.3	74.4	774	727	571
10	47	49	46	80.2	78.5	80.7	18	20	19	87.9	88.4	79.1	650	626	610
$\bar{x}$	49	48	44	80.8	80.6	80.5	19	18	17	83.0	79.5	71.8	729	686	583
LP group															
11	44	44	40	80.4	80.1	78.2	17	17	15	78.5	70.5	64.1	700	727	534
12	51	49	42	79.5	81.0	79.8	20	21	17	86.3	80.4	82.6	667	683	436
13	48	47	38	76.6	77.1	75.2	17	16	14	80.4	78.9	71.1	733	685	475
14	48	46	34	79.4	80.6	78.3	17	16	12	86.1	78.0	67.1	666	657	449
15	48	49	37	78.8	79.6	76.9	19	19	14	73.3	73.6	62.3	740	714	483
16	42	45	24	78.5	78.1	75.4	15	15	08	80.8	80.3	73.5	573	588	282
17	45	47	37	78.3	78.7	78.8	15	17	13	85.7	78.0	70.5	629	679	492
18	48	44	41	81.0	81.4	78.5	19	17	16	83.5	78.5	68.7	672	665	519
19	48	45	39	79.2	78.7	79.1	18	16	13	88.8	85.4	70.1	719	613	522
20	46	47	37	79.2	79.4	77.9	17	17	14	83.1	79.3	70.6	677	661	470
$\bar{x}$	47	46	37	79.1	79.4	77.9	17	17	14	83.1	79.3	70.6	677	661	470
Checks															
21	49	49	39	81.6	83.0	81.5	19	19	14	82.6	78.2	76.4	711	707	485
22	39	45	23	76.6	77.3	77.2	15	16	11	85.8	80.4	73.5	467	579	383
23	50	47	41	80.3	80.4	79.9	18	18	16	85.0	80.7	73.2	707	652	480

Table 47. Average agronomic data for 13 plant and ear characters in testcrosses of 20 selected inbred lines and three checks evaluated in three plant densities at Ames, 1967

	Low[a]	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
	Yield in q/ha			No. ear/plant			Plant height (cm)			Ear height (cm)			Ear length (mm)		
HP group															
01	69.1	82.8	70.3	1.00	0.98	0.90	210	213	210	90	94	94	167	174	138
02	64.8	85.2	81.7	0.98	1.00	0.96	213	212	214	93	88	93	191	185	155
03	68.5	79.9	72.1	0.98	0.96	0.86	210	214	209	92	91	96	185	181	139
04	68.8	81.2	64.4	1.00	0.92	0.78	208	211	210	83	88	92	195	176	120
05	65.1	74.2	66.8	0.98	0.98	0.86	206	213	212	87	91	90	186	177	138
06	63.9	68.1	79.9	0.96	0.88	0.86	216	215	218	98	100	102	183	158	142
07	71.3	71.8	89.4	1.00	0.94	0.96	214	211	218	98	93	100	196	174	155
08	65.1	74.6	70.9	1.00	0.96	0.88	205	202	205	93	95	98	198	189	149
09	64.8	67.3	74.5	0.98	0.94	0.94	203	202	197	86	86	91	193	177	153
10	69.1	79.9	82.3	1.00	0.98	0.98	218	220	223	98	97	102	200	183	157
$\bar{x}$	67.1	76.5	75.2	0.99	0.95	0.90	210	211	212	92	92	96	189	177	145
LP group															
11	62.0	76.3	63.8	0.94	0.98	0.76	205	211	212	90	92	94	193	188	128
12	64.2	75.5	60.8	0.96	0.98	0.84	207	207	207	91	95	94	176	175	118
13	65.1	57.9	62.0	1.00	0.82	0.70	208	209	208	89	87	92	190	143	123
14	66.0	76.3	75.7	0.98	0.94	0.86	216	213	212	99	97	98	201	188	144
15	64.5	70.2	71.5	0.96	0.92	0.90	202	209	210	95	93	98	180	158	129
16	61.4	66.5	44.1	0.94	0.80	0.62	207	212	205	87	91	88	201	161	100
17	70.7	74.2	68.0	0.98	0.96	0.84	205	206	205	91	95	92	212	190	147
18	59.5	78.3	66.2	0.96	0.94	0.82	210	217	209	100	102	100	190	177	138
19	73.8	79.9	76.3	0.96	0.98	0.86	216	209	212	95	94	93	214	199	150
20	63.9	74.6	62.2	0.96	0.96	0.78	216	216	221	96	96	102	187	180	125
$\bar{x}$	65.1	73.0	65.1	0.96	0.93	0.80	209	211	210	93	94	95	194	176	130
Checks															
21	63.9	75.9	61.4	0.98	0.96	0.86	202	201	201	84	88	92	184	178	124
22	62.3	74.6	68.6	0.96	0.94	0.80	226	231	222	99	105	101	187	181	148
23	60.1	65.3	62.2	0.84	0.90	0.82	212	214	211	94	94	90	176	158	133

[a]Plant densities.

Table 47 (Continued)

	Low[a]	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
HP group	Ear diameter (mm)			Shelling percent			Kernel depth (mm)			300-kernel wt (g)			No. seed/plant		
01	51	49	42	81.9	82.7	81.0	21	20	17	92.2	90.2	68.4	724	678	513
02	51	50	45	81.2	83.2	81.2	21	21	19	88.3	83.4	75.5	706	747	549
03	49	48	40	81.8	80.9	81.5	20	19	16	79.8	79.8	65.1	830	735	557
04	50	50	36	82.7	82.8	81.2	20	20	14	80.0	78.5	64.7	841	759	502
05	50	47	29	81.9	82.6	81.0	20	19	15	78.8	70.6	63.9	800	773	536
06	47	43	39	82.2	82.7	81.6	20	18	16	83.3	77.6	70.6	650	646	564
07	50	46	45	83.1	82.3	83.3	21	20	18	77.2	77.3	68.4	897	686	661
08	50	46	39	80.8	79.9	80.3	19	17	14	80.3	75.5	63.7	785	731	563
09	49	45	42	81.9	81.8	82.0	21	19	17	84.8	76.8	63.9	743	654	587
10	50	49	44	81.3	81.6	82.4	21	21	18	93.9	83.6	74.2	730	703	563
$\bar{x}$	50	47	41	81.9	82.1	81.6	20	19	16	83.9	79.3	68.4	771	711	561
LP group															
11	47	46	33	81.7	81.8	80.5	20	18	12	78.6	72.9	73.3	741	776	441
12	49	48	38	82.3	82.1	81.5	21	19	15	85.0	86.4	74.8	730	650	412
13	49	40	36	79.1	79.6	79.2	20	15	15	82.0	76.4	69.4	770	564	455
14	49	46	40	80.9	81.4	82.1	20	19	15	85.6	81.2	70.8	749	690	538
15	49	47	44	82.0	81.2	80.7	21	20	18	72.5	74.9	63.7	863	704	564
16	46	41	26	80.6	82.0	76.5	18	18	10	82.8	82.9	72.7	713	582	304
17	46	45	37	81.5	80.8	79.5	18	17	14	82.9	81.6	66.7	823	666	507
18	47	46	38	81.3	81.9	82.0	19	20	16	84.8	80.7	69.0	707	715	463
19	49	47	39	81.4	81.1	81.3	19	19	16	91.0	79.0	67.1	760	750	576
20	47	45	35	82.3	81.5	81.4	19	18	15	85.5	85.0	78.8	718	646	398
$\bar{x}$	48	45	37	81.3	81.3	80.5	19	18	15	83.1	80.1	70.6	757	674	466
Checks															
21	50	47	39	82.2	82.5	82.1	21	19	15	77.4	78.4	67.5	798	708	460
22	47	45	37	79.9	79.7	80.0	19	17	14	89.5	85.4	77.5	672	642	429
23	46	44	38	80.1	81.7	81.0	17	18	15	81.3	75.7	71.9	710	634	433

Table 47 (Continued)

	Silking date[b]			Shedding date[b]			(Silking date-shedding date) +10		
	Low[a]	Med	High	Low	Med	High	Low	Med	High
HP group									
01	30.2	30.8	33.2	30.2	30.4	31.6	10.0	10.4	11.6
02	29.6	28.6	30.8	30.8	29.6	29.6	8.8	9.0	11.2
03	31.6	32.2	33.8	31.6	31.8	32.4	10.4	10.4	11.4
04	31.0	31.6	32.8	31.0	30.6	31.4	10.0	11.0	11.4
05	30.2	29.8	32.4	30.8	30.0	30.4	9.4	9.8	12.0
06	31.6	31.8	33.4	31.6	30.6	32.0	10.0	11.2	11.4
07	31.0	31.8	31.8	31.0	30.6	31.2	10.0	11.2	10.6
08	31.4	31.4	32.8	31.4	31.0	31.8	10.0	10.4	11.0
09	29.6	29.6	31.4	29.0	29.4	30.4	10.6	10.2	11.0
10	31.0	30.4	32.4	30.6	31.2	31.6	10.4	9.2	10.8
$\bar{x}$	30.7	30.8	32.5	30.8	30.6	31.2	9.9	10.3	11.3
LP group									
11	31.6	31.6	33.8	31.4	31.2	31.6	10.2	10.4	12.2
12	31.4	31.0	33.2	31.0	30.4	31.4	10.4	10.6	11.8
13	31.0	31.4	34.0	31.0	31.0	32.0	10.0	10.4	12.0
14	31.4	31.4	33.4	31.6	31.2	31.6	9.8	10.2	11.8
15	31.4	32.0	33.0	31.4	31.0	31.8	10.0	11.0	11.2
16	31.2	31.6	34.8	30.2	30.4	31.8	11.0	11.2	13.0
17	31.0	31.6	34.2	30.6	31.0	31.6	10.4	10.6	12.6
18	31.2	31.6	34.0	31.6	31.0	31.8	9.6	10.6	12.2
19	30.8	31.4	32.2	30.0	31.0	30.8	10.8	10.4	11.4
20	29.8	30.0	32.6	29.4	29.6	30.6	10.4	10.4	12.0
$\bar{x}$	31.1	31.4	33.5	30.8	30.8	31.5	10.3	10.6	12.0
Checks									
21	30.0	30.2	31.2	30.2	30.4	30.8	9.8	9.8	10.4
22	32.0	32.8	34.6	31.8	31.0	31.6	10.2	11.8	13.0
23	31.0	31.8	33.2	31.2	31.0	31.2	9.8	10.8	12.0

[b]Coded.

Table 48. Average agronomic data for 10 plant and ear characters in testcrosses of 20 selected inbred lines and three checks evaluated in three plant densities at Kanawha, 1968

	Low[a]	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
	Yield in q/ha			No. ear/plant			Plant height (cm)			Ear height (cm)			Ear length (mm)		
HP group															
01	64.2	78.3	86.4	1.00	1.00	0.96	225	231	228	96	100	98	182	176	148
02	59.5	73.0	80.5	1.00	1.00	1.00	221	229	229	90	93	98	172	161	143
03	65.7	77.5	84.6	1.00	1.00	1.00	222	230	233	95	99	98	191	179	151
04	73.2	87.3	87.6	1.04	1.00	1.00	220	229	230	95	95	99	203	189	164
05	64.8	73.0	79.9	1.00	1.00	1.00	220	224	230	93	94	100	187	178	150
06	66.3	69.0	85.8	1.00	0.98	0.92	231	237	235	110	111	109	188	167	149
07	72.2	79.9	89.4	1.00	1.00	0.98	231	238	239	102	110	114	207	187	168
08	68.8	78.3	93.0	1.00	1.02	1.00	223	226	225	103	106	107	202	191	176
09	65.4	73.4	84.6	1.00	1.00	1.00	209	216	218	84	93	96	200	180	162
10	62.6	74.6	88.8	1.00	1.00	1.00	223	240	236	103	109	107	181	170	153
$\bar{x}$	66.6	76.4	86.1	1.00	1.00	0.99	223	230	230	97	101	103	191	178	156
LP group															
11	66.3	72.6	76.3	0.98	0.98	0.92	228	226	229	93	97	98	193	174	145
12	67.9	65.7	77.5	1.00	0.96	0.96	225	218	230	96	102	103	183	150	135
13	62.9	72.2	84.6	1.00	1.00	1.00	221	226	227	95	96	99	189	169	153
14	65.7	79.9	91.2	0.98	0.98	0.98	232	238	241	108	111	119	199	195	171
15	60.8	66.1	74.5	1.00	0.94	0.90	226	229	233	101	109	109	170	152	130
16	70.4	72.6	87.6	1.00	0.94	0.98	217	225	228	90	94	95	204	200	173
17	64.2	72.2	75.7	0.98	0.98	0.92	223	226	225	99	101	105	203	186	151
18	64.2	76.7	76.9	0.98	1.00	0.92	226	236	228	109	111	112	191	187	146
19	68.2	72.6	82.9	0.98	1.00	0.96	221	227	226	96	102	100	210	192	172
20	63.9	69.0	75.1	0.96	1.00	0.92	230	233	236	103	102	110	186	174	142
$\bar{x}$	65.5	72.0	80.2	0.99	0.98	0.95	225	228	230	99	102	105	193	178	152
Checks															
21	67.6	75.9	87.6	1.02	1.00	1.00	212	220	219	87	92	94	198	178	157
22	45.6	57.9	51.3	0.90	0.94	0.86	238	243	241	104	105	107	153	154	127
23	58.9	73.8	81.1	0.94	0.98	0.90	224	228	229	98	96	103	177	173	148

[a]Plant densities.

Table 48 (Continued)

	Low[a]	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
	Ear diameter (mm)			Shelling percent			Kernel depth (mm)			300-kernel wt (g)			No. seed/plant		
HP group															
01	52	51	46	82.5	82.2	83.2	21	21	19	92.0	90.0	82.1	677	640	535
02	53	52	48	80.4	81.9	82.5	21	20	19	94.7	92.7	86.1	611	579	474
03	52	51	48	83.6	83.1	83.6	21	20	19	83.1	80.3	74.6	768	712	570
04	51	51	46	82.5	84.2	83.2	21	21	18	83.6	79.3	72.4	848	809	608
05	50	49	46	83.0	81.5	83.0	19	19	18	83.0	75.2	70.8	755	714	567
06	50	47	43	81.9	81.3	83.3	20	19	17	86.4	84.3	77.4	744	608	554
07	51	50	45	84.1	84.6	83.8	22	22	18	84.6	79.3	70.1	830	743	640
08	51	49	47	80.9	80.9	81.2	19	18	18	84.8	79.1	72.8	786	729	640
09	50	49	47	82.3	83.6	82.7	20	20	20	84.0	79.4	74.1	754	680	574
10	52	51	47	81.1	81.9	81.6	22	21	19	101.5	92.0	82.1	600	600	548
$\bar{x}$	51	50	46	82.2	82.5	82.8	21	20	19	87.8	83.2	76.3	737	681	571
LP group															
11	49	47	42	81.8	81.3	82.2	20	19	17	84.4	78.5	68.3	763	678	564
12	53	48	46	82.8	83.0	82.9	23	20	20	88.6	83.2	83.7	744	589	466
13	51	50	47	80.5	80.7	80.2	19	19	17	85.9	87.6	75.2	710	657	568
14	49	49	46	81.7	82.8	82.5	19	19	18	92.0	85.1	78.8	692	694	582
15	52	48	45	80.8	80.6	81.2	22	20	20	77.8	79.1	73.3	756	616	512
16	52	46	45	81.5	82.4	81.7	21	19	17	93.8	86.3	79.5	727	618	555
17	48	46	40	81.0	81.5	82.4	18	18	14	89.5	85.4	79.6	692	624	483
18	49	49	42	81.7	81.5	82.9	20	20	16	88.6	82.4	72.2	704	683	538
19	48	47	42	81.2	80.7	81.7	17	18	16	91.7	86.2	77.2	724	621	540
20	48	48	43	81.2	81.4	81.5	19	20	18	95.2	91.3	87.7	651	563	430
$\bar{x}$	50	48	44	81.4	81.6	81.9	20	19	17	88.8	84.5	77.6	716	634	524
Checks															
21	52	50	48	81.9	83.2	83.8	20	20	20	83.2	75.9	70.5	791	736	627
22	43	44	35	80.5	79.6	76.8	17	18	13	91.6	86.1	79.1	481	493	327
23	48	49	42	81.5	82.8	82.0	19	20	16	87.9	82.2	80.4	652	660	508

Table 49. Average agronomic data for 13 plant and ear characters in testcrosses of 20 selected inbred lines and three checks evaluated in three plant densities at Ames, 1968

	Low[a]	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
	Yield in q/ha			No. ear/plant			Plant height (cm)			Ear height (cm)			Ear length (mm)		
HP group															
01	66.3	78.3	81.1	1.00	0.98	0.96	217	208	213	88	90	93	189	183	150
02	67.0	75.0	79.9	1.10	1.00	1.00	208	215	218	84	88	89	202	179	151
03	69.1	75.5	90.6	1.00	0.98	1.00	210	208	212	89	93	96	200	179	167
04	68.2	78.7	84.1	1.00	1.00	1.00	208	214	213	85	90	91	198	187	166
05	68.5	68.5	73.3	1.04	0.98	0.98	209	210	211	84	84	88	203	178	150
06	73.2	82.2	92.4	1.00	1.00	0.98	214	217	219	97	94	102	198	187	165
07	68.6	83.2	91.2	1.00	1.00	1.00	207	217	217	89	93	94	200	198	166
08	69.7	76.3	75.1	1.00	1.00	0.98	199	206	211	95	97	103	210	199	170
09	63.5	74.2	76.9	1.00	1.00	1.00	194	203	198	81	85	89	195	182	160
10	69.1	77.9	93.0	1.02	1.00	1.00	221	221	225	99	94	104	201	176	162
$\bar{x}$	68.3	77.0	83.8	1.02	0.99	0.99	209	212	214	89	91	95	200	185	161
LP group															
11	70.7	78.7	85.2	1.00	0.98	0.98	207	208	213	85	87	91	204	186	160
12	69.7	82.8	88.8	0.96	1.00	1.00	204	209	210	90	89	96	180	170	147
13	67.6	76.3	83.5	1.00	0.98	0.98	198	209	208	85	87	91	196	175	153
14	67.9	79.5	79.3	0.96	1.00	0.92	214	222	213	99	103	99	218	208	165
15	65.4	73.8	84.1	0.92	1.00	1.00	204	210	214	92	92	97	172	168	150
16	67.3	73.4	79.1	1.00	0.96	0.96	205	211	204	88	86	83	221	202	176
17	66.6	76.7	78.7	1.00	1.00	1.00	208	210	208	85	93	97	209	201	173
18	71.6	78.3	76.9	1.00	1.00	1.00	209	209	217	96	98	102	209	194	162
19	75.3	79.5	80.5	1.00	1.00	0.96	211	213	215	93	96	94	221	214	181
20	64.5	76.3	85.8	0.96	0.92	0.96	204	215	222	90	90	101	190	185	154
$\bar{x}$	68.6	77.5	82.0	0.98	0.98	0.97	206	212	212	90	92	95	202	190	162
Checks															
21	63.9	75.9	80.5	0.94	1.00	1.00	197	203	201	82	83	90	184	173	161
22	61.4	72.6	91.2	0.96	1.00	1.00	218	222	228	94	92	104	194	186	172
23	69.7	72.6	85.2	0.98	1.00	1.00	213	215	216	89	91	97	196	179	161

[a]Plant densities.

Table 49 (Continued)

	Low[a]	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
HP group	Ear diameter (mm)			Shelling percent			Kernel depth (mm)			300-kernel wt (g)			No. seed/plant		
01	51	50	45	81.7	82.9	82.7	20	20	18	99.9	90.9	82.7	644	614	491
02	52	51	47	81.4	81.8	82.6	21	19	17	96.2	88.9	78.8	675	621	513
03	51	49	48	83.0	82.5	83.8	21	19	18	87.7	81.8	73.3	766	681	626
04	51	49	45	82.6	83.2	83.4	20	19	17	84.9	78.3	68.6	780	742	617
05	52	47	44	82.6	82.5	82.5	20	17	15	83.3	71.7	65.2	802	701	558
06	51	48	45	83.1	83.6	83.7	22	20	18	92.2	88.9	77.5	767	676	603
07	50	48	47	84.0	84.7	83.5	20	20	19	83.5	80.9	73.8	799	758	623
08	51	48	44	81.2	81.4	80.5	20	17	14	84.5	75.8	61.4	801	740	615
09	49	49	45	83.5	83.5	82.7	19	19	17	83.3	75.6	68.5	739	722	566
10	50	50	47	81.6	82.9	83.6	19	20	19	101.9	93.7	79.7	656	615	589
$\bar{x}$	51	49	46	82.5	83.0	83.0	20	19	17	89.7	82.7	73.0	743	687	580
LP group															
11	49	48	45	82.8	82.9	82.6	19	19	17	84.0	81.3	71.7	817	711	596
12	51	52	49	83.0	83.4	83.5	21	22	21	98.0	97.2	90.5	690	627	493
13	50	48	46	80.0	80.1	80.3	19	18	16	91.1	85.8	77.8	719	655	545
14	48	48	42	82.1	82.8	83.0	19	17	15	88.8	82.1	77.0	739	717	520
15	49	51	49	81.6	81.4	81.2	20	20	19	82.5	74.1	70.0	772	734	616
16	50	47	42	83.4	82.1	81.8	19	16	16	87.7	81.3	74.7	745	664	540
17	49	47	43	81.4	82.1	82.1	18	17	15	92.0	84.4	71.5	708	668	553
18	50	48	45	82.6	83.0	81.2	19	18	17	90.2	82.6	74.5	773	700	522
19	48	46	43	83.0	81.8	81.7	17	16	16	92.6	84.3	70.3	792	693	578
20	48	49	45	81.6	81.4	82.8	19	19	18	99.3	92.4	90.1	629	608	478
$\bar{x}$	49	48	45	82.2	82.1	82.0	19	17	17	90.6	84.6	76.8	738	678	544
Checks															
21	48	50	47	82.9	81.2	82.5	19	20	17	88.2	82.1	76.8	705	680	516
22	46	48	46	80.1	80.1	80.8	17	17	18	93.5	95.9	85.6	633	558	535
23	50	49	46	82.1	82.6	82.4	19	19	18	89.3	86.2	80.9	758	622	531

Table 49 (Continued)

	Silking date[b] Low[a]	Med	High	Shedding date[b] Low	Med	High	(Silking date-shedding date) +10 Low	Med	High
HP group									
01	26.4	27.0	28.8	25.8	25.8	26.6	10.6	11.2	12.2
02	26.0	26.8	27.6	26.2	26.4	26.8	9.8	10.4	10.8
03	28.0	27.8	29.8	27.6	27.0	27.6	10.4	10.8	12.2
04	26.6	27.0	29.0	26.6	26.2	27.2	10.0	10.8	11.8
05	27.0	27.0	29.4	26.4	25.8	27.2	10.6	11.2	12.2
06	27.8	27.4	29.6	27.6	26.8	27.0	10.2	10.6	12.6
07	27.6	27.8	28.8	27.0	26.8	26.4	10.6	11.0	12.4
08	28.0	28.4	30.0	27.2	27.0	27.8	10.8	11.4	12.2
09	26.0	26.2	28.8	25.4	25.2	26.8	10.6	11.0	12.4
10	28.6	26.8	28.2	27.0	26.0	27.4	11.6	10.8	10.8
$\bar{x}$	26.9	27.2	29.0	26.7	26.3	27.1	10.5	10.9	12.1
LP group									
11	27.6	27.4	28.8	27.2	26.6	27.2	10.4	10.8	11.6
12	27.0	27.4	28.8	26.2	26.2	26.8	10.8	11.2	12.0
13	27.0	27.0	29.4	25.8	26.0	27.2	11.2	11.0	12.2
14	28.0	28.4	29.2	28.0	26.0	28.2	10.0	12.4	11.0
15	28.2	28.6	29.0	27.6	27.0	27.8	10.6	11.6	11.2
16	27.2	28.0	29.8	26.6	26.2	26.4	10.6	11.8	13.4
17	29.0	29.0	30.2	27.2	27.8	28.2	11.8	11.2	12.0
18	27.8	28.4	29.8	27.8	26.8	27.6	10.0	11.6	12.2
19	27.6	27.2	30.0	27.2	26.2	26.6	10.4	11.0	13.4
20	26.4	26.4	28.8	25.6	25.8	26.2	10.8	10.6	12.6
$\bar{x}$	27.5	27.8	29.4	26.9	26.5	27.2	10.7	11.3	12.2
Checks									
21	25.8	25.8	27.4	25.6	26.0	26.2	10.2	9.8	11.2
22	29.2	29.2	31.2	28.4	27.6	28.8	10.8	11.6	12.4
23	28.0	27.8	28.8	27.4	26.0	27.4	10.6	11.8	11.4

[b]Coded.

Table 50. Average agronomic data for 10 plant and ear characters in testcrosses of 20 selected inbred lines and three checks evaluated in three plant densities at Ankeny, 1968

	Low[a]	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
	Yield in q/ha			No. ear/plant			Plant height (cm)			Ear height (cm)			Ear length (mm)		
HP group															
01	56.1	62.4	63.2	1.00	1.00	0.98	221	221	237	96	98	109	180	172	143
02	54.6	56.3	59.0	1.00	1.00	0.98	200	219	234	98	95	102	185	173	144
03	55.2	61.6	54.2	0.96	1.00	0.96	219	222	228	101	99	105	183	179	145
04	56.1	58.7	56.8	1.00	0.98	0.94	219	220	218	97	99	98	191	172	142
05	55.5	53.0	54.0	1.00	0.98	1.00	219	226	230	97	107	104	194	172	151
06	66.3	68.5	66.2	1.00	1.00	0.98	227	235	233	102	111	106	189	183	152
07	62.3	64.5	65.0	1.00	1.00	1.00	235	226	231	109	105	110	194	179	145
08	55.2	53.0	54.2	1.00	0.96	0.98	229	217	232	106	101	107	200	178	163
09	53.0	52.6	50.7	1.00	1.00	0.96	216	218	225	97	96	101	190	172	137
10	62.3	62.0	67.4	1.00	1.00	0.98	237	237	233	111	107	107	189	173	150
$\bar{x}$	57.7	59.3	59.0	1.00	0.99	0.98	222	224	230	101	102	105	190	175	147
LP group															
11	58.6	53.8	53.1	1.00	0.98	0.90	228	223	236	103	97	104	196	166	139
12	58.0	64.9	55.4	1.00	1.00	0.92	226	220	227	102	102	103	174	163	115
13	54.6	60.0	49.5	0.95	0.98	0.86	226	225	224	106	98	98	180	167	116
14	63.2	58.7	68.0	1.00	1.00	1.00	230	233	231	112	111	112	209	186	163
15	53.6	57.1	53.1	0.94	1.00	0.88	222	226	236	100	100	110	170	157	121
16	54.2	48.9	37.0	1.00	0.90	0.66	222	222	221	95	97	95	205	168	107
17	54.9	54.7	51.3	1.00	1.00	0.88	221	218	229	99	99	104	202	180	132
18	58.6	58.7	54.2	1.00	0.94	0.94	226	225	230	103	103	108	198	165	139
19	62.3	60.0	57.2	0.98	0.96	0.94	221	224	232	102	105	100	215	190	160
20	58.3	61.2	50.7	0.98	0.98	0.84	223	221	232	100	104	104	192	178	128
$\bar{x}$	57.6	56.8	53.0	0.99	0.97	0.87	225	224	230	102	101	104	194	172	132
Checks															
21	52.1	55.1	51.9	0.98	0.98	0.92	209	209	219	93	90	102	177	161	124
22	59.5	60.4	57.8	0.98	0.94	0.86	238	232	240	104	102	112	187	167	134
23	59.2	57.5	51.3	1.00	0.92	0.86	222	228	233	96	105	105	191	162	125

[a]Plant densities.

Table 50 (Continued)

HP group	Low[a]	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
	Ear diameter (mm)			Shelling percent			Kernel depth (mm)			300-kernel wt (g)			No. seed/plant		
01	50	49	44	83.9	83.2	83.5	19	19	17	79.7	75.9	72.2	685	610	438
02	50	48	44	82.5	82.8	82.8	18	18	16	79.2	68.1	62.0	673	610	483
03	48	48	42	84.1	84.6	82.3	18	17	15	76.4	71.5	62.0	699	635	443
04	49	46	41	84.0	83.9	81.3	18	17	16	68.8	61.9	63.3	788	701	447
05	48	45	43	83.3	83.5	82.4	18	16	15	66.1	61.1	55.7	815	640	494
06	50	47	43	84.1	84.7	82.8	21	18	17	87.6	82.9	65.4	735	607	510
07	49	47	44	85.3	84.6	84.6	20	18	17	78.4	73.4	73.5	748	651	447
08	47	43	42	81.2	81.7	82.1	16	14	13	69.4	61.4	52.7	769	640	541
09	48	46	40	83.9	80.9	82.2	19	18	15	73.4	68.3	67.9	701	569	379
10	50	47	43	82.9	83.6	82.2	20	18	16	93.7	74.4	64.0	626	611	529
$\bar{x}$	49	47	43	83.5	83.4	82.6	19	17	16	77.3	69.9	63.9	724	627	471
LP group															
11	48	43	37	83.6	83.5	82.7	18	16	15	71.9	62.6	62.2	787	636	428
12	51	50	41	83.8	82.7	83.2	21	21	18	83.9	80.4	82.4	671	603	344
13	47	45	37	80.3	81.0	81.0	17	16	13	81.8	75.6	73.8	649	585	337
14	48	46	44	84.5	83.7	82.4	18	18	16	86.7	72.5	64.7	707	597	522
15	48	48	39	83.0	83.1	82.1	19	19	15	74.8	68.8	65.5	690	614	413
16	47	40	28	82.9	82.9	80.0	16	15	9	77.1	72.6	71.2	683	497	273
17	46	44	35	83.3	82.9	82.4	16	16	13	75.7	71.7	67.7	700	560	392
18	48	43	40	84.7	84.0	83.0	18	17	15	77.9	70.4	68.1	724	603	421
19	46	43	40	84.7	84.0	83.0	18	17	15	77.9	70.4	68.1	724	603	421
20	47	46	36	83.6	82.8	81.2	18	18	13	85.0	82.8	79.5	665	550	328
$\bar{x}$	48	45	38	83.3	83.0	82.0	18	17	14	79.6	72.5	70.4	702	589	388
Checks															
21	49	46	41	84.8	84.2	82.4	18	17	16	73.3	70.7	69.2	688	574	377
22	48	43	36	81.9	81.3	81.6	18	16	14	87.9	84.2	80.7	658	526	366
23	49	44	36	83.4	82.1	82.2	19	17	15	80.8	75.0	69.6	708	571	369

Table 51. Analyses of variance for 13 plant and ear characters in testcrosses of 20 selected inbred lines and three checks evaluated at Ames, 1966

Source of variations	Degrees of freedom	Mean squares: Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Replications	4	3197.1**	0.19	483.53*	38.50*	7.67*
Densities	2	47149.7**	3.52**	23.36	70.04*	126.76**
Replications x densities	8	176.5	0.37	67.55	9.95	1.44
Entries	22	534.3**	0.44**	174.80**	85.84**	3.35**
Selections vs checks	1	990.3**	0.81**	156.76*	66.88**	8.30**
Among selections[b]	19	536.9**	0.40**	162.68**	89.62**	3.40**
HP vs LP	1	481.7*	1.35**	7.78	12.88	0.50
Among HP	9	475.3**	0.14	200.06**	102.05**	1.71**
Among LP	9	604.7**	0.54**	143.17**	85.71**	5.41**
Among checks	2	281.7*	0.66**	296.02**	59.45**	0.44
(M14&C103) vs (M14xC103)	1	249.4	0.01	0.01	4.50	0.01
M14 vs C103	1	313.9	1.31**	592.03**	114.41**	0.87
Densities x entries	44	133.3*	0.19**	37.50	4.53	0.91
Densities x (sel vs ch)	2	382.4*	0.20	0.77	1.33	1.57
Linear	1	63.4	0.26	0.44	0.02	1.04
Quadratic	1	701.3**	0.13	1.09	2.63	2.09
Densities x (among selections)	38	125.5	0.21**	41.87	4.36	0.94
Densities x (HP vs LP)	2	79.4	0.36*	15.32	7.01	1.12
Linear	1	133.2	0.63**	27.56	10.82	1.57
Quadratic	1	25.6	0.08	3.07	3.20	0.68

[a]Observed values were multiplied by 10^2.

[b]Orthogonal comparisons based on reasons lines were selected for the study (Table 1).

Table 51 (Continued)

Source of variations	Degrees of freedom	Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x (among HP)	18	58.2	0.05	11.14	3.70	0.27
Linear	9	78.5	0.04	18.59	5.91	0.30
Quadratic	9	37.8	0.06	3.68	1.49	0.23
Densities x (among LP)	18	198.0**	0.34**	75.56**	4.72	1.59**
Linear	9	280.4**	0.41**	140.21**	6.33	2.50**
Quadratic	9	115.5	0.28**	10.91	3.10	0.67
Densities x (among checks)	4	83.0	0.10	14.36	7.77	0.34
Densities x{(M14&C103)vs(M14xC103)}	2	52.0	0.01	14.91	9.33	0.09
Linear	1	45.6	0.01	2.43	12.40	0.17
Quadratic	1	58.3	0.00	27.39	6.25	0.00
Densities x (M14 vs C103)	2	114.1	0.19	13.81	6.21	0.60
Linear	1	228.0	0.36	15.21	0.81	0.00
Quadratic	1	0.1	0.01	12.40	11.60	1.19
Error	264	90.6	0.10	31.71	5.52	0.73
Total	344					
c.v. %		10.76	7.44	6.33	5.50	10.14

Source of variations	Degrees of freedom	Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Replications	4	12.19	1.30*	0.90	289.90**	4436.0
Densities	2	369.12**	1.69**	53.80**	675.76**	330242.2**
Replications x densities	8	5.59	0.21	1.03	6.82	5386.4
Entries	22	19.86**	3.08**	5.55**	87.47**	11195.2**
Selections vs checks	1	27.69**	2.22**	11.58**	7.64	11462.0**
Among selections[b]	19	19.40**	2.87**	5.11**	97.34**	11302.9**
HP vs LP	1	72.16**	24.50**	17.71**	76.70**	25717.7**

Table 51 (Continued)

Source of variations	Degrees of freedom	Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Among HP	9	7.33**	0.94**	2.00	111.51**	7315.2**
Among LP	9	25.53**	2.39**	61.45**	85.45**	13689.0**
Among checks	2	20.86**	5.52**	6.66**	33.60**	10037.9**
(M14&C103) vs (M14xC103)	1	0.11	1.72*	0.98	0.13	2450.0
M14 vs C103	1	41.61**	9.33**	12.33**	67.07**	17625.8**
Densities x entries	44	4.15*	0.45*	1.44	4.91	2179.5**
Densities x (sel vs ch)	2	3.31	0.31	0.95	0.44	5100.7*
Linear	1	2.40	0.20	1.27	0.00	477.3
Quadratic	1	4.22	0.41	0.63	0.87	9724.0**
Densities x (among selections)	38	4.57*	0.48*	1.55	5.04	2066.9**
Densities x (HP vs LP)	2	3.22	0.88	0.89	0.62	782.9
Linear	1	3.03	1.75*	0.40	0.21	1505.5
Quadratic	1	3.40	0.00	1.37	1.03	60.2
Densities x (among HP)	18	1.00	0.35	0.97	5.52	1280.3
Linear	9	0.89	0.46	0.62	1.93	1589.8
Quadratic	9	1.11	0.24	1.32	9.11	970.8
Densities x (among LP)	18	8.28**	0.56*	2.20*	5.05	2996.2**
Linear	9	11.10**	0.72*	2.96**	7.16	4744.9**
Quadratic	9	5.45	0.41	1.44	2.93	1247.6
Densities x (among checks)	4	0.58	0.24	0.77	5.96	178.9
Densities x {(M14&C103) vs (M14xC103)}	2	0.27	0.44	1.33	3.23	2075.8
Linear	1	0.40	0.01	0.96	5.28	2575.5
Quadratic	1	0.13	0.87	1.69	1.18	1576.1
Densities x (M14 vs C103)	2	0.89	0.04	0.21	8.69	1501.9
Linear	1	1.69	0.00	0.25	8.29	2106.8
Quadratic	1	0.08	0.08	0.16	9.09	897.1
Error	264	2.84	0.29	1.13	4.90	1170.0
Total	344					
c.v. %		8.23	1.43	12.54	5.88	10.89

Table 51 (Continued)

Source of variations	Degrees of freedom	Mean squares: Silking date	Mean squares: Shedding date	Mean squares: (Silking date-shedding date) +10
Replications	4	20.61**	40.83**	3.73**
Densities	2	5.96**	0.21	8.41**
Replications x densities	8	0.13	0.22	0.27
Entries	22	2.91**	3.80**	1.41**
Selections vs checks	1	2.18**	6.05**	0.95
Among selections[b]	19	2.65**	3.88**	1.48**
HP vs LP	1	11.09**	1.87*	3.75**
Among HP	9	2.79**	3.91**	1.35**
Among LP	9	1.57**	4.08**	1.35**
Among checks	2	5.78**	1.95**	1.02*
(M14&C103)vs(M14xC103)	1	0.88*	0.38	0.11
M14 vs C103	1	10.67**	3.53**	1.93**
Densities x entries	44	0.30	0.46*	0.21
Densities x (sel vs ch)	2	0.06	0.05	0.14
Linear	1	0.11	0.03	0.26
Quadratic	1	0.01	0.07	0.02
Densities x (among selections)	38	0.31*	0.52*	0.18
Densities x (HP vs LP)	2	0.63	1.19*	0.13
Linear	1	1.16*	2.21**	0.23
Quadratic	1	0.11	0.18	0.03
Densities x (among HP)	18	0.24	0.54	0.07
Linear	9	0.23	0.22	0.04
Quadratic	9	0.26	0.32	0.10
Densities x (among LP)	18	0.35*	0.69**	0.30
Linear	9	0.49*	0.87**	0.42
Quadratic	9	0.21	0.52	0.19

Table 51 (Continued)

Source of variations	Degrees of freedom	Mean squares: Silking date	Shedding date	(Silking date-shedding date) +10
Densities x (among checks)	4	0.23	0.14	0.50
Densities x{(M14&C103)vs(M14xC103)}	2	0.38	0.25	0.81
Linear	1	0.21	0.21	0.00
Quadratic	1	0.54	0.28	1.60*
Densities x (M14 vs C103)	2	0.09	0.03	0.20
Linear	1	0.16	0.04	0.36
Quadratic	1	0.01	0.01	0.05
Error	264	0.21	0.31	0.28
Total	344			
c.v.%		4.10	5.32	10.08

Table 52. Analyses of variance for 10 plant and ear characters in testcrosses of 20 selected inbred lines and three checks evaluated at Kanawha, 1967

Source of variations	Degrees of freedom	Mean squares: Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Replications	4	5262.1*	1.80	848.81*	13.69	20.94
Densities	2	31460.0**	5.12*	140.84	4.63	118.03**
Replications x densities	8	1197.4	0.81	143.77	28.40	6.15
Entries	22	577.3**	0.69**	45.83**	21.73**	3.74**
Selections vs checks	1	863.2**	0.80	9.45	0.16	7.04**
Among selections[b]	19	456.7**	0.64**	36.39*	20.65**	3.79**
HP vs LP	1	3244.3**	5.28**	23.81	23.56	4.61*
Among HP	9	88.2	0.10	56.35*	29.53**	2.00*
Among LP	9	515.4**	0.67**	17.82	11.45	5.49**
Among checks	2	1579.9**	1.14**	153.68**	42.72*	1.66
(M14&C103)vs(M14xC103)	1	621.9*	0.57	96.14*	41.71*	2.61
M14 vs C103	1	2537.9**	1.71**	211.23**	43.74*	0.71
Densities x entries	44	105.2	0.32	32.29	11.49	1.25*
Densities x (sel vs ch)	2	193.8	0.31	67.74	33.81*	1.23
Linear	1	6.7	0.04	11.71	0.98	0.02
Quadratic	1	47.5	0.22	0.52	1.02	1.26
Densities x (among selections)	38	98.7	0.32*	33.91*	12.19	1.07
Densities x (HP vs LP)	2	724.6**	1.78**	86.52*	27.20	5.91**
Linear	1	829.9**	2.50**	1.68	0.00	7.80**
Quadratic	1	619.3*	1.05*	171.36**	54.41*	4.03*
Densities x (among HP)	18	80.9	0.08	23.49	15.51	0.29
Linear	9	96.1	0.11	21.08	9.36	0.39
Quadratic	9	65.7	0.07	25.89	21.66*	0.18

[a]Observed values were multiplied by 10^2.

[b]Orthogonal comparisons based on reasons lines were selected for the study (Table 1).

Table 52 (Continued)

Source of variations	Degrees of freedom			Mean squares				
				Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x (among LP)		18		47.0	0.40*	38.48*	7.21	1.32
Linear			9	35.4	0.53**	45.77*	7.96	1.28
Quadratic			9	58.5	0.27	31.19	6.45	1.35
Densities x (among checks)	4			206.1	0.41	30.05	10.09	3.15**
Densities x{(M14&C103)vs(M14xC103)}		2		212.7	0.40	2.78	8.60	2.58*
Linear			1	270.8	0.40	0.56	11.60	2.80
Quadratic			1	154.6	0.40	4.99	5.60	2.35
Densities x (M14 vs C103)		2		199.6	0.41	57.33	11.58	3.73*
Linear			1	299.3	0.25	32.49	4.41	5.57**
Quadratic			1	99.8	0.56	82.16	18.75	1.89
Error	264			113.2	0.21	22.35	9.39	0.82
Total	344							
c.v. %				14.39	10.85	5.12	7.44	11.75
				Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Replications	4			99.50	1.24	14.96	134.98**	46156.5
Densities	2			384.08**	4.38	71.10**	814.87**	211423.2**
Replications x densities	8			33.20	2.02	6.52	13.99	12400.5
Entries	22			25.08**	7.10**	8.35**	66.99**	11160.3**
Selections vs checks		1		16.48	0.01	5.45*	21.23*	28137.4**
Among selections[b]		19		23.11**	6.21**	7.99**	76.34**	9121.1**
HP vs LP			1	204.61**	50.09**	47.53**	2.78	60890.9**
Among HP			9	3.78	3.06**	1.85	95.12**	5514.0**
Among LP			9	22.24**	4.48**	9.73**	65.85**	6976.0**
Among checks		2		48.09**	19.08**	13.21**	0.55	22044.2**

Table 52 (Continued)

Source of variations	Degrees of freedom		Mean squares				
			Ear diameter[a]	Shelling percent	Kernal depth[a]	300-kernel weight	No. seeds per plant
(M14&C103)vs(M14xC103)		1	25.44*	0.95	6.97**	0.03	6674.0*
M14 vs C103		1	70.73**	37.20**	19.44**	1.05	37414.4**
Densities x entries	44		6.83	0.64	1.35	7.06	1893.5
Densities x (sel vs ch)	2		12.07	1.42	1.86	8.20	1665.3
Linear		1	1.47	0.90	0.30	4.29	9.7
Quadratic		1	6.90	0.14	1.37	6.74	4059.2
Densities x(among selections)	38		7.10	0.69	1.42	7.51*	1826.9
Densities x (HP vs LP)	2		50.71**	2.40**	7.60**	2.17	10213.7**
Linear		1	69.10**	1.58	8.84**	4.12	9187.0*
Quadratic		1	32.00**	3.22**	6.35*	0.21	11240.4**
Densities x (among HP)	18		1.99	0.60	0.99	5.57	1115.3
Linear		9	2.00	0.54	1.17	7.26	1610.1
Quadratic		9	2.10	0.66	0.76	3.88	620.5
Densities x (among LP)	18		7.47	0.60	1.19	10.04	1606.7
Linear		9	7.76	0.76	1.21	11.93	1385.8
Quadratic		9	7.29	0.44	1.16	8.14	1827.5
Densities x(among checks)	4		5.60	0.20	0.93	3.59	2455.7
Densities x{(M14&C103)vs(M14xC103)}	2		6.27	0.18	1.67	1.79	2065.5
Linear		1	1.20	0.19	1.47	2.03	1713.6
Quadratic		1	11.33	0.16	1.87	1.55	2417.4
Densities x (M14 vs C103)	2		4.93	0.22	0.18	5.39	2845.9
Linear		1	5.29	0.13	0.09	9.42	5055.2
Quadratic		1	4.56	0.31	0.27	1.35	636.5
Error	264		4.81	0.48	1.12	4.83	1621.2
Total	344						
c.v.%			10.91	1.94	14.06	6.29	14.36

Table 53. Analyses of variance for 13 plant and ear characters in testcrosses of 20 selected inbred lines and three checks evaluated at Ames, 1967

Source of variations	Degrees of freedom			Mean squares				
				Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Replications	4			925.0	0.15	43.28	49.03	3.59
Densities	2			54746.8**	9.17**	12.32	42.27	176.30**
Replications x densities	8			1990.5	0.10	39.50	20.38	3.93
Entries	22			377.4**	0.62**	103.10**	54.34**	3.04**
Selections vs checks		1		808.4**	0.53	58.23*	0.54	2.23
Among selections[b]		19		376.5**	0.64**	66.71**	48.28**	3.18**
HP vs LP			1	1713.1**	3.75**	14.41	10.25	1.80
Among HP			9	176.2*	0.26	94.76**	56.60**	1.67**
Among LP			9	428.4**	0.68**	44.46**	44.19**	4.85**
Among checks		2		170.1	0.49	471.20**	138.78**	2.04**
(M14&C103)vs(M14xC103)			1	338.0	0.80*	4.91	10.89	2.54
M14 vs C103			1	2.2	0.17	937.50**	266.67**	1.54
Densities x entries	44			129.5	0.22	7.33	5.07	0.98*
Densities x (sel vs ch)		2		25.1	0.12	8.20	10.59	0.40
Linear			1	7.0	0.10	10.64	1.60	0.72
Quadratic			1	43.1	0.13	5.75	19.65	0.07
Densities x (among selections)		38		142.7*	0.23	7.50	4.24	1.04*
Densities x (HP vs LP)			2	162.2	0.94**	1.92	10.44	4.90**
Linear			1	295.9	1.44**	0.96	12.54	9.49**
Quadratic			1	28.4	0.43	2.88	8.32	0.31
Densities x (among HP)			18	147.8*	0.13	6.50	3.80	0.66
Linear			9	99.7	0.19	6.07	2.43	0.73
Quadratic			9	195.9*	0.07	6.93	5.17	0.58

[a]Observed values were multiplied by 10^2.

[b]Orthogonal comparisons based on reasons lines were selected for the study (Table 1).

Table 53 (Continued)

Source of variations	Degrees of freedom	Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x (among LP)	18	135.5*	0.25	9.11	4.00	1.00
Linear	9	94.7	0.35*	8.85	2.89	0.99
Quadratic	9	176.3	0.16	9.41	5.10	1.01
Densities x (among checks)	4	56.1	0.14	5.26	10.18	0.66
Densities x{(M14&C103)vs(M14xC103)}	2	65.0	0.25	0.32	12.33	0.58
Linear	1	6.8	0.48	0.56	24.65	0.09
Quadratic	1	123.2	0.28	0.05	0.00	1.07
Densities x (M14 vs C103)	2	47.2	0.03	10.22	8.03	0.74
Linear	1	76.0	0.04	1.69	9.00	1.12
Quadratic	1	18.8	0.01	18.75	7.05	0.36
Error	264	91.6	0.17	11.51	7.72	0.65
Total	344					
c.v.%		12.57	10.02	3.59	6.62	10.74
		Ear diameter[a]	**Shelling percent**	**Kernel depth[a]**	**300-kernel weight**	**No. seeds per plant**
Replications	4	9.47	0.45	6.17	67.97	5467.8
Densities	2	596.02**	2.49	119.00**	1164.72	402079.8**
Replications x densities	8	9.77	0.61	2.35	1034.03	6248.8
Entries	22	16.92**	2.38**	5.45**	50.51**	8110.2**
Selections vs checks	1	8.50	1.39	5.31*	5.16	17167.1**
Among selections[b]	19	18.48**	2.22**	5.72**	49.83**	7981.2**
HP vs LP	1	115.37**	9.38**	27.47**	13.05	34310.9**
Among HP	9	8.00**	1.27**	3.60**	63.81**	4162.7*
Among LP	9	18.19**	2.37**	5.43**	39.95**	8874.1**

Table 53 (Continued)

Source of variations	Degrees of freedom	Mean squares				
		Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	per plant
Among checks	2	6.33	4.37**	2.92	79.59**	4808.0
(M14&C103)vs(M14xC103)	1	6.24	0.04	2.00	18.24	1327.8
M14 vs C103	1	6.41	8.69**	3.84	140.94**	8288.2*
Densities x entries	44	0.48	0.63**	1.18	9.82	2612.0*
Densities x (sel vs ch)	2	0.14	0.53	0.02	10.39	1261.2
Linear	1	0.17	1.06	0.04	18.88	1596.9
Quadratic	1	0.11	0.00	0.00	1.91	925.5
Densities x (among selections)	38	5.51*	0.69**	1.46	10.35	2889.8*
Densities x (HP vs LP)	2	13.09*	0.34	1.99	16.00	8559.9**
Linear	1	20.45*	0.64	2.70	31.79*	16184.5**
Quadratic	1	5.72	0.04	1.28	0.20	935.2
Densities x (among HP)	18	3.78	0.35	8.65**	8.96	2561.6
Linear	9	4.00	0.05	0.83	9.73	2629.5
Quadratic	9	3.56	0.65	0.90	8.18	2493.7
Densities x (among LP)	18	6.38*	0.95	2.00*	11.12	2587.8
Linear	9	7.78*	1.11**	2.42*	15.01*	2046.6
Quadratic	9	4.97	0.79*	1.58	7.23	3129.1
Densities x (among checks)	4	0.38	0.23	0.56	4.47	647.9
Densities x{(M14&C103)vs(M14xC103)}	2	0.72	0.40	1.04	5.65	140.5
Linear	1	1.33	0.24	2.62	0.79	58.1
Quadratic	1	0.11	0.57	0.18	10.50	223.0
Densities x (M14 vs C103)	2	0.05	0.05	0.08	3.30	1155.3
Linear	1	0.04	0.00	0.75	1.00	2265.8
Quadratic	1	0.05	0.10	0.00	5.60	44.9
Error	264	3.66	0.35	1.16	7.36	1723.6
Total	344					
c.v. %		9.59	1.62	12.83	7.81	14.27

Table 53 (Continued)

Source of variations	Degrees of freedom			Mean squares: Date silking	Mean squares: Date shedding	Mean squares: (Silking date-shedding date) +10
Replications	4			0.22	1.40	1.16
Densities	2			30.06**	2.85*	15.52**
Replications x densities	8			0.72	0.38	1.39
Entries	22			2.09**	1.02**	0.62**
Selections vs checks		1		0.33	0.05	0.13
Among selections		19		1.84**	1.09**	0.50**
HP vs LP			1	6.40**	0.49	3.36**
Among HP			9	2.40**	1.46**	0.37
Among LP			9	0.77	0.78**	0.30
Among checks		2		5.38**	0.78**	2.09**
(M14&C103)vs(M14xC103)			1	0.08	0.06	0.00
M14 vs C103			1	10.67**	1.50**	4.17**
Densities x entries	44			0.22	0.15	0.24
Densities x (sel vs ch)		2		0.20	0.13	0.18
Linear			1	0.01	0.24	0.14
Quadratic			1	0.38	0.02	0.23
Densities x (among selections)		38		0.23	0.16	0.23
Densities x (HP vs LP)		2		0.61	0.96**	0.40
Linear			1	1.16	0.14	0.48
Quadratic			1	0.07	0.05	0.23
Densities x (among HP)		18		0.21	0.20	0.32
Linear			9	0.19	0.32*	0.29
Quadratic			9	0.24	0.08	0.34
Densities x (among LP)		18		0.20	0.12	0.13
Linear			9	0.27	0.13	0.16
Quadratic			9	0.13	0.11	0.10
Densities x (among checks)		4		0.13	0.08	0.34
Densities x{(M14&C103)vs(M14xC103)}		2		0.02	0.02	0.04

Table 53 (Continued)

Source of variations	Degrees of freedom	Mean squares		
		Date silking	Date shedding	(Silking date-shedding date) +10
Linear	1	0.03	0.01	0.08
Quadratic	1	0.01	0.02	0.00
Densities x (M14 vs C103)	2	0.25	0.14	0.65
Linear	1	0.49	0.16	1.31*
Quadratic	1	0.00	0.12	0.08
Error	264	0.33	0.15	0.25
Total	344			
c.v. %		4.03	2.82	10.35

Table 54. Analyses of variance for 10 plant and ear characters in testcrosses of 20 selected inbred lines and three checks evaluated at Kanawha, 1968

Source of variations	Degrees of freedom	Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Replications	4	173.9	0.16	104.92	119.57	1.24
Densities	2	30072.4**	0.62**	280.34	182.93*	80.79**
Replications x densities	8	119.5	0.05	69.94	39.87	0.34
Entries	22	605.1**	2.17**	109.31**	122.47**	4.98**
Selections vs checks	1	2763.4**	0.93**	2.51	56.91**	10.88**
Among selections[b]	19	258.9**	0.11**	82.41**	122.15**	4.31**
HP vs LP	1	906.4**	1.07**	1.29	46.82**	0.16
Among HP	9	267.3**	0.05	113.77**	131.75**	3.07**
Among LP	9	178.6**	0.07	60.07**	121.59**	6.01**
Among checks	2	2814.1**	0.88**	418.26**	155.30**	8.54**
(M14&C103)vs(M14xC103)	1	418.6**	0.04	5.78	2.42	0.48
M14 vs C103	1	5209.7**	1.71**	830.73**	308.17**	16.60**
Densities x entries	44	63.7**	0.07	7.80	4.47	0.27
Densities x (sel vs ch)	2	155.7*	0.07	1.55	3.21	0.36
Linear	1	164.0*	0.00	2.41	0.39	0.45
Quadratic	1	147.4*	0.14	0.69	6.02	0.26
Densities x (among selections)	38	59.4*	0.05	8.72	4.65	0.26
Densities x (HP vs LP)	2	105.8	0.07	10.21	1.57	0.50
Linear	1	125.3	0.12	17.95	0.90	0.85
Quadratic	1	76.2	0.02	2.47	2.24	0.05
Densities x (among HP)	18	55.8	0.02	6.27	5.78	0.14
Linear	9	63.1	0.04	7.53	8.48*	0.14
Quadratic	9	48.6	0.01	5.01	3.08	0.14

[a]Observed values were multiplied by 10^2.

[b]Orthogonal comparisons based on reasons lines were selected for the study (Table 1).

Table 54 (Continued)

Source of variations	Degrees of freedom			Mean squares				
				Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x (among LP)		18		58.5	0.06	9.83	3.91	0.36
Linear			9	51.0	0.05	4.87	2.38	0.31
Quadratic			9	66.0	0.08	14.79*	5.44	0.41
Densities x (among checks)	4			58.0	0.06	2.17	3.43	0.34
Densities x{(M14&C103)vs(M14xC103)}		2		24.1	0.03	2.66	4.85	0.06
Linear			1	41.8	0.00	0.03	0.08	0.06
Quadratic			1	6.4	0.05	5.29	9.61	0.05
Densities x (M14 vs C103)		2		91.7	0.09	1.60	2.00	0.62
Linear			1	25.0	0.01	5.25	3.61	0.59
Quadratic			1	158.4*	0.16	0.96	0.40	0.64
Error	264			35.75	0.05	7.17	4.23	0.32
Total	344							
c.v. %				7.61	5.10	2.62	4.56	7.25
				Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Replications	4			3.71	3.65*	1.39	16.88*	2039.6
Densities	2			193.92**	0.97	35.12**	741.00**	183761.7**
Replications x densities	8			3.04	0.89	0.49	4.32	1486.6
Entries	22			14.98**	3.72**	4.95**	72.55**	14573.1**
Selections vs checks		1		46.42**	4.23**	10.27**	9.66	26166.8**
Among selections[b]		19		8.43**	2.69**	3.84**	76.40**	9019.9**
HP vs LP			1	57.62**	11.90**	10.42**	22.16*	22126.1**
Among HP			9	4.33**	2.85**	2.07**	100.60**	12976.0**
Among LP			9	7.09**	1.52**	4.88**	58.23**	3607.0**

Table 54 (Continued)

Source of variations	Degrees of freedom		Mean squares: Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Among checks	2		62.10**	13.19**	12.84**	67.44**	61532.1**
(M14&C103)vs(M14xC103)		1	1.39	2.46**	0.04	11.75	1909.6
M14 vs C103		1	121.50**	23.92**	25.63**	123.13**	121154.5**
Densities x entries	44		1.45	0.52*	0.69	4.82	969.0*
Densities x (sel vs ch)	2		3.69*	1.25*	1.35	3.43	2125.7*
Linear		1	0.05	1.22	0.19	0.29	835.3
Quadratic		1	7.33*	1.27	2.50*	6.55	3416.1*
Densities x (among selections)	38		1.19	0.30	0.59	5.11	967.7*
Densities x (HP vs LP)	2		1.61	0.03	0.13	0.25	1139.0
Linear		1	2.92	0.02	0.23	0.24	1726.6
Quadratic		1	0.30	0.03	0.02	0.15	551.3
Densities x (among HP)	18		0.05	0.45	0.43	3.48	986.7
Linear		9	0.67	0.25	0.42	5.68	1287.5*
Quadratic		9	0.33	0.65*	0.44	1.28	685.9
Densities x (among LP)	18		1.83	0.18	0.81	7.29*	929.6
Linear		9	0.98	0.13	0.53	9.82**	1214.7
Quadratic		9	2.68*	0.24	1.08	4.76	644.5
Densities x (among checks)	4		2.79	2.18**	1.34	2.77	403.8
Densities x{(M14&C103)vs(M14xC103)}	2		0.63	0.35	0.36	5.01	142.1
Linear		1	0.12	0.63	0.40	8.57	74.0
Quadratic		1	1.14	0.06	0.32	1.45	210.2
Densities x (M14 vs C103)	2		4.94*	4.02**	2.33*	0.53	665.3
Linear		1	4.00	7.90**	2.89*	0.01	20.2
Quadratic		1	5.88*	0.14	1.76	1.04	1310.4
Error	264		1.17	0.33	0.58	3.69	645.2
Total	344						
c.v. %			5.04	1.57	8.90	5.18	8.92

Table 55. Analyses of variance for 13 plant and ear characters in testcrosses of 20 selected inbred lines and three checks evaluated at Ames, 1968

Source of variations	Degrees of freedom			Mean squares				
				Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Replications	4			343.4	0.05	43.84	9.16	0.81
Densities	2			36981.2**	0.04	194.14*	202.65**	84.18**
Replications x densities	8			92.0	0.07	30.01	19.55	0.34
Entries	22			144.7**	0.09	103.38**	70.68**	3.23**
Selections vs checks		1		215.3*	0.01	30.34	4.86	1.74*
Among selections[b]		19		152.7**	0.10*	77.04**	70.00**	3.55**
HP vs LP			1	0.0	0.60**	32.86	13.25	1.41*
Among HP			9	230.1**	0.06	123.16**	80.35**	0.98**
Among LP			9	92.4*	0.09	35.82**	68.94**	6.35**
Among checks		2		33.2	0.02	390.22**	110.15**	1.01*
(M14&C103)vs(M14xC103)			1	65.7	0.02	18.81	4.30	0.01
M14 vs C103			1	0.7	0.01	761.63**	216.00**	2.00**
Densities x entries	44			63.3	0.06	10.34	6.12	0.31
Densities x (sel vs ch)		2		186.6*	0.24*	0.24	13.58	1.29**
Linear			1	324.9**	0.39*	0.00	10.52	2.11**
Quadratic			1	48.3	0.08	0.48	16.64	0.41
Densities x (among selections)		38		50.6	0.06	11.41	6.10	0.27
Densities x (HP vs LP)			2	23.0	0.10	5.03	1.61	0.26
Linear			1	30.6	0.12	3.14	1.76	0.02
Quadratic			1	15.4	0.08	6.91	1.45	0.49
Densities x (among HP)			18	51.5	0.04	10.58	3.92	0.28
Linear			9	63.1	0.05	10.45	1.42	0.27
Quadratic			9	39.9	0.02	10.70	6.42	0.30

[a]Observed values were multiplied by 10^2.

[b]Orthogonal comparisons based on reasons lines were selected for the study (Table 1).

Table 55 (Continued)

Source of variations	Degrees of freedom	Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x (among LP)	18	52.7	0.07	12.96	8.81	0.28
Linear	9	88.3	0.07	16.32	11.85*	0.38
Quadratic	9	17.0	0.06	9.60	5.76	0.17
Densities x (among checks)	4	122.7*	0.01	5.18	2.60	0.14
Densities x{(M14&C103)vs(M14xC103)}	2	142.8	0.02	2.63	2.06	0.27
Linear	1	181.0	0.03	4.81	0.75	0.53
Quadratic	1	104.7	0.01	0.44	3.36	0.01
Densities x (M14 vs C103)	2	102.5	0.01	7.73	3.14	0.02
Linear	1	151.3	0.01	9.00	1.21	0.00
Quadratic	1	53.8	0.00	6.45	5.07	0.02
Error	264	48.0	0.06	10.10	6.07	0.27
Total	344					
c.v. %		8.49	5.70	3.36	5.98	6.32

Source of variations	Degrees of freedom	Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Replications	4	1.32	0.54	1.04**	140.27*	1094.4
Densities	2	123.29**	0.14	26.37**	1221.58**	187282.4**
Replications x densities	8	1.26	0.30	0.06	25.79	941.6
Entries	22	4.74**	2.65**	4.49**	120.28**	6687.1**
Selections vs checks	1	0.03	4.84**	0.13	102.69**	16907.4**
Among selections[b]	19	5.18*	2.42**	4.95**	126.79**	6468.1**
HP vs LP	1	13.82**	6.73**	5.28**	72.42**	4113.5**
Among HP	9	1.80	2.14**	2.71**	147.03**	7610.4**
Among LP	9	7.96**	2.21**	7.15**	112.59**	5587.3**

Table 55 (Continued)

Source of variations	Degrees of freedom			Mean squares				
				Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Among checks	2			2.92	3.73**	2.34**	67.29**	3657.2**
(M14&C103)vs(M14xC103)			1	2.00	2.45**	2.00*	4.85	2151.7
M14 vs C103			1	3.84	5.01**	2.67*	129.74**	5162.7**
Densities x entries	44			1.45	0.34	0.79	7.00	778.3
Densities x (sel vs ch)		2		5.86**	0.37	0.23	25.97*	536.1
Linear			1	11.40**	0.01	3.99**	49.02**	69.2
Quadratic			1	0.31	0.73	0.46	2.11	1003.0
Densities x (among selections)	38			1.24	0.33	0.74	6.20	655.4
Densities x (HP vs LP)		2		1.63	5.03**	0.43	11.60	1443.1
Linear			1	0.73	0.90	0.84	22.44	2499.6*
Quadratic			1	2.52	0.15	0.01	0.76	386.6
Densities x (among HP)		18		1.11	0.29	0.84*	5.02	733.3
Linear			9	1.44	0.41	1.46**	7.56	943.1
Quadratic			9	0.78	0.17	0.22	2.48	523.4
Densities x (among LP)		18		1.32	0.35	0.67	6.78	490.0
Linear			9	2.00	0.51	0.82	10.52	576.0
Quadratic			9	0.65	0.20	0.52	3.05	403.9
Densities x (among checks)	4			1.19	0.37	0.59	5.09	2066.5*
Densities x{(M14&C103)vs(M14xC103)}		2		2.01	0.37	0.06	1.06	157.5
Linear			1	3.20	0.00	0.03	0.47	2279.8
Quadratic			1	0.81	0.73	0.09	1.65	870.3
Densities x (M14 vs C103)		2		0.38	0.38	1.13	9.13	2557.9*
Linear			1	0.49	0.29	1.69	3.06	2088.5
Quadratic			1	0.27	0.46	0.56	15.19	3027.4*
Error	264			1.13	0.32	0.49	6.53	648.0
Total	344							
c.v. %				4.97	1.52	8.51	6.85	8.68

Table 55 (Continued)

Source of variations	Degrees of freedom			Mean squares: Date silking	Mean squares: Date shedding	Mean squares: (Silking date-shedding date) +10
Replications	4			10.60**	9.37*	0.59
Densities	2			22.54**	2.85	13.25**
Replications x densities	8			1.43	1.43	0.86
Entries	22			1.95**	1.39**	0.47*
Selections vs checks		1		0.09	0.43	0.14
Among selections		19		1.27**	1.15**	0.42*
HP vs LP			1	2.90**	0.91*	0.49
Among HP			9	1.23**	0.80**	0.33
Among LP			9	1.13**	1.53**	0.50*
Among checks		2		9.37**	4.11**	1.15*
(M14&C103)vs(M14xC103)			1	0.02	0.06	0.14
M14 vs C103			1	18.73**	8.17**	2.16**
Densities x entries	44			0.21	0.14	0.25
Densities x (sel vs ch)		2		0.07	0.07	0.14
Linear			1	0.14	0.00	0.15
Quadratic			1	0.00	0.13	0.13
Densities x (among selections)		38		0.23	0.14	0.25
Densities (HP vs LP)			2	0.06	0.06	0.01
Linear			1	0.00	0.03	0.01
Quadratic			1	0.11	0.10	0.00
Densities x (among HP)			18	0.28	0.15	0.21
Linear			9	0.41	0.20	0.37
Quadratic			9	0.16	0.10	0.05
Densities x (among LP)			18	0.19	0.13	0.33
Linear			9	0.21	0.18	0.43
Quadratic			9	0.17	0.69**	0.22

Table 55 (Continued)

Source of variations	Degrees of freedom	Mean squares		
		Date silking	Date shedding	(Silking date-shedding date) +10
Densities x (among checks)	4	0.11	0.22	0.28
Densities x{(M14&C103)vs(M14xC103)}	2	0.19	0.24	0.39
Linear	1	0.33	0.08	0.08
Quadratic	1	0.04	0.40	0.69
Densities x (M14 vs C103)	2	0.03	0.20	0.18
Linear	1	0.04	0.01	0.09
Quadratic	1	0.01	0.40	0.27
Error	264	0.28	0.15	0.26
Total	344			
c.v. %		4.25	3.22	10.21

Table 56. Analyses of variance for 10 plant and ear characters in testcrosses of 20 selected inbred lines and three checks evaluated at Ankeny, 1968

Source of variations	Degrees of freedom			Mean squares				
				Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Replications	4			523.0	0.13	133.56	45.93	0.62
Densities	2			48784.0**	3.01**	339.66*	86.60	165.94**
Replications x densities	8			228.6	0.15	61.77	29.80	1.06
Entries	22			319.6**	0.35**	94.21**	48.91**	3.00**
Selections vs checks		1		63.2	0.73**	0.27	16.91	7.56**
Among selections[b]		19		346.5**	0.35**	62.37**	44.91**	3.02**
HP vs LP			1	353.3**	2.48**	3.36	0.35	3.24**
Among HP			9	407.5**	0.03	103.86**	47.38**	0.62
Among LP			9	284.8**	0.45**	27.44	47.28**	5.40**
Among checks		2		191.9*	0.12	443.61**	102.88**	0.58
(M14&C102)vs(M14xC103)			1	3.0	0.06	18.40	3.92	0.01
M14 vs C103			1	380.8**	0.17	868.81**	201.84**	1.14
Densities x entries	44			46.2	0.17**	24.69	11.35	0.65**
Densities x (sel vs ch)		2		4.1	0.14	1.65	23.32	0.15
Linear			1	4.6	0.26	2.30	43.73	0.29
Quadratic			1	3.5	0.02	1.00	2.92	0.01
Densities x (among selections)		38		49.6	0.19**	27.30	10.53	0.73**
Densities x (HP vs LP)		2		132.3**	1.08**	13.68	3.48	5.01**
Linear			1	258.1*	1.76**	21.90	6.89	9.88**
Quadratic			1	6.5	0.39*	5.46	0.06	0.14
Densities x (among HP)		18		3.5	0.01	4.88	1.34	0.02
Linear			9	28.8	0.02	65.86**	8.81	0.17
Quadratic			9	34.0	0.03	22.16	15.50	0.22

[a]Observed values were multiplied by 10^2.

[b]Orthogonal comparisons based on reasons lines were selected for the study (Table 1).

Table 56 (Continued)

Source of variations	Degrees of freedom			Mean squares: Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x (among LP)		18		58.5	0.26**	12.10	9.70	0.78**
Linear			9	35.1	0.43**	14.99	11.75	1.05**
Quadratic			9	81.9	0.10	9.20	7.64	0.51
Densities x (among checks)	4			38.0	0.06	11.41	13.08	0.18
Densities x{(M14&C103)vs(M14xC103)}		2		47.8	0.07	12.70	25.92	0.34
Linear			1	92.9	0.08	10.45	0.00	0.57
Quadratic			1	2.7	0.05	14.95	51.84*	0.10
Densities x (M14 vs C103)		2		28.0	0.05	10.10	0.24	0.03
Linear			1	50.4	0.09	19.36	0.36	0.00
Quadratic			1	5.6	0.00	0.85	0.12	0.06
Error	264			46.7	0.09	22.33	12.71	0.37
Total	344							
c.v. %				10.84	7.10	4.68	7.78	8.15

Source of variations	Degrees of freedom			Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Replications	4			6.21	0.40	3.23	131.24**	1234.5
Densities	2			440.80**	7.99*	68.80**	675.51**	486137.2**
Replications x densities	8			6.14	1.02	1.74	9.15	3903.3
Entries	22			15.02**	2.44**	6.15**	115.39**	6261.6**
Selections vs checks		1		8.30	0.58	0.28	163.80**	16759.0**
Among selections[b]		19		16.16**	2.40**	6.95**	110.57**	6266.7**
HP vs LP			1	107.20**	2.58*	11.79**	223.80**	34081.7**
Among HP			9	4.25	4.54**	5.05**	125.61**	3449.5**
Among LP			9	18.03**	0.24	8.38**	82.96**	5993.4**

Table 56 (Continued)

Source of variations	Degrees of freedom		Mean squares				
			Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Among checks	2		7.24	3.72**	1.22	136.92**	964.5
M14&C103)vs(M14xC103)		1	0.98	0.05	0.50	12.73	614.8
M14 vs C103		1	13.50*	7.39**	1.93	261.10**	1314.2
Densities x entries	44		3.52	0.49	0.72	13.96**	1530.0
Densities x (sel vs ch)	2		4.55	0.20	0.30	10.60	659.2
Linear		1	9.00	0.05	0.03	18.06	1207.0
Quadratic		1	0.09	0.34	0.56	3.13	111.5
Densities x (among selections)	38		3.64*	0.52	0.73	15.27**	1368.1*
Densities x (HP vs LP)	2		18.49**	0.57	4.80**	29.98	5186.9**
Linear		1	30.98**	0.57	0.84	48.22**	9684.5**
Quadratic		1	5.99	0.01	3.96*	11.73	689.3
Densities x (among HP)	18		0.08	0.07	0.03	2.29	197.0
Linear		9	0.57	0.57	0.31	34.19**	2734.5**
Quadratic		9	1.05	0.81	0.34	7.17	811.8
Densities x (among LP)	18		8.42*	0.37	0.97	8.21	1272.6
Linear		9	6.80**	0.53	1.40*	12.86	1684.0*
Quadratic		9	2.85	0.21	0.53	3.57	861.3
Densities x (among checks)	4		1.87	0.42	0.79	3.21	198.0
Densities x{(M14&C103)vs(M14xC103)}	2		2.41	0.15	0.41	5.22	235.4
Linear		1	4.81	0.01	0.56	10.42	461.3
Quadratic		1	0.00	0.29	0.25	0.01	9.4
Densities x (M14 vs C103)	2		1.34	0.70	1.17	1.19	158.5
Linear		1	2.56	1.04	2.25	2.28	84.6
Quadratic		1	0.12	0.35	0.08	0.10	232.3
Error	264		2.39	0.52	0.73	6.88	865.1
Total	344						
c.v. %			7.77	1.93	11.36	8.05	11.38

Table 57. Analyses of variance for 13 plant and ear characters in testcrosses of 20 selected inbred lines and three checks evaluated at Ames, 1966

Source of variations	Degrees of freedom			Mean squares				
				Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Replications	4			3197.1**	0.19	483.53*	38.50*	7.67*
Densities	2			47197.7**	3.52**	23.36	70.04*	126.76**
Replications x densities	8			176.5	0.37	67.55	9.95	1.44
Entries	22			534.3**	0.44**	174.80**	85.84**	3.35**
Selections vs checks		1		990.3**	0.81**	156.76*	66.88**	8.30**
Among selections[b]		19		536.9**	0.40**	162.68**	89.62**	3.40**
Group 0 vs (1&2&3&4)			1	1.9	0.16	70.56	22.62*	5.07**
(1&2) vs (3&4)			1	137.6	0.30	34.56	3.03	2.86*
1 vs 2			1	29.2	0.10	254.89**	183.05**	0.35
3 vs 4			1	867.1**	0.39*	280.22**	100.02**	0.12
Among 0			1	0.5	0.01	24.00	16.01	0.33
Among 1			4	405.2**	0.24	42.64	66.91**	6.82**
Among 2			3	255.3*	0.04	20.52	5.54	3.20**
Among 3			4	974.8**	0.27*	526.47**	199.83**	1.03
Among 4			3	959.5**	1.48**	31.19	97.78**	4.94**
Among checks		2		281.7*	0.66**	296.02**	59.45**	0.44
(M14&C103) vs (M14xC103)			1	249.4	0.01	0.01	4.50	0.01
M14 vs C103			1	313.9	1.31**	529.03**	114.41**	0.87
Densities x entries	44			133.3*	0.19**	37.50	4.53	0.91
Densities x (sel vs ch)		2		382.4*	0.20	0.77	1.33	1.57
Linear			1	63.4	0.26	0.44	0.02	1.04
Quadratic			1	701.3**	0.13	1.09	2.63	2.09

[a]Observed values were multiplied by 10^2.

[b]Orthogonal comparisons based on breeding groups.

Table 57 (Continued)

Source of variations	Degrees of freedom	Mean squares: Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x (among selections)	38	125.5	0.21**	41.87	4.36	0.94
Densities x {0 vs (1&2&3&4)}	2	120.5	0.05	6.06	0.56	0.87
Linear	1	241.1	0.09	11.52	0.71	1.58
Quadratic	1	0.9	0.01	0.60	0.42	0.17
Densities x {(1&2) vs (3&4)}	2	35.5	0.62**	57.71	18.44*	2.50*
Linear	1	38.4	0.93**	115.20	21.16	4.44*
Quadratic	1	32.5	0.31	0.21	15.72	0.53
Densities x (1 vs 2)	2	82.1	0.03	56.35	5.16	0.86
Linear	1	127.4	0.01	112.67	11.31	1.69
Quadratic	1	36.8	0.04	0.01	0.00	0.03
Densities x (3 vs 4)	2	97.7	0.44*	2.54	7.11	1.13
Linear	1	109.6	0.34	3.60	13.77	1.05
Quadratic	1	85.9	0.54*	1.48	0.45	1.19
Densities x among 0	2	40.5	0.05	17.36	2.01	0.01
Linear	1	20.3	0.04	25.00	4.00	0.03
Quadratic	1	60.8	0.05	9.72	0.01	0.00
Densities x among 1	8	148.2	0.03	16.40	5.55	0.33
Linear	4	223.1*	0.04	28.32	9.06	0.61
Quadratic	4	74.5	0.02	4.48	2.03	0.05
Densities x among 2	6	178.7	0.12	346.83**	1.53	0.91
Linear	3	172.7	0.09	339.16**	2.82	1.12
Quadratic	3	184.7	0.15	21.16	0.25	0.71
Densities x among 3	8	59.7	0.09	8.56	3.73	0.48
Linear	4	110.2	0.14	10.27	5.33	0.78
Quadratic	4	9.2	0.04	6.85	2.15	0.18
Densities x among 4	6	212.6*	0.63**	5.08	2.43	2.16**
Linear	3	325.3*	0.80**	5.61	1.35	3.03*
Quadratic	3	99.9	0.49**	4.54	3.50	1.29

Table 57 (Continued)

Source of variations	Degrees of freedom	Mean squares: Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x (among checks)	4	83.0	0.10	14.36	7.77	0.34
Densities x {(M14&C103)vs(M14xC103)}	2	52.0	0.01	14.91	9.33	0.09
Linear	1	45.6	0.01	2.43	12.40	0.17
Quadratic	1	58.3	0.00	27.39	6.25	0.00
Densities x (M14 vs C103)	2	114.1	0.19	13.81	6.21	0.60
Linear	1	228.0	0.36	15.21	0.81	0.00
Quadratic	1	0.1	0.01	12.40	11.60	1.19
Error	264	90.6	0.10	31.71	5.52	0.73
Total	344					
c.v. %		10.76	7.44	6.33	5.50	10.14
		Ear diameter[a]	Shelling percent	Kernal depth[a]	300-kernel weight	No. seeds per plant
Replications	4	12.19	1.30*	0.90	289.90**	4436.0
Densities	2	369.12**	1.59**	53.80**	675.76**	330242.2**
Replications x densities	8	5.59	0.21	1.03	6.82	5386.4
Entries	22	19.86**	3.08**	5.55**	87.47**	11195.2**
Selections vs checks	1	27.69**	2.22**	11.58**	7.64	11462.0**
Among selections[b]	19	19.40**	2.87**	5.11**	97.34**	11302.9**
Group 0 vs (1&2&3&4)	1	20.73**	2.40**	7.35**	199.76**	8867.1**
(1&2) vs (3&4)	1	41.61**	0.92	2.58	175.68**	27014.5**
1 vs 2	1	0.37	11.85**	0.61	21.28*	3523.6
3 vs 4	1	22.90**	0.04	6.49*	342.98**	590.3
Among 0	1	6.00	0.03	0.67	19.87*	410.0
Among 1	4	7.22*	0.87*	2.47	100.28**	4298.7**

Table 57 (Continued)

Source of variations	Degrees of freedom	Mean squares: Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Among 2	3	4.18	6.85**	3.28*	88.96**	16023.4**
Among 3	4	20.04**	2.09**	6.22**	73.59**	7705.7**
Among 4	3	51.42**	2.30**	11.62**	42.45**	26087.4**
Among checks	2	20.86**	5.52**	6.66**	33.60**	10037.9**
(M14&C103) vs (M14xC103)	1	0.11	1.72*	0.98	0.13	2450.0
M14 vs C103	1	41.61**	9.33**	12.33**	67.07**	17625.8**
Densities x entries	44	4.15*	0.45*	1.44	4.91	2179.5**
Densities x (sel vs ch)	2	3.31	0.31	0.95	0.44	5100.7*
Linear	1	2.40	0.20	1.27	0.00	477.3
Quadratic	1	4.22	0.41	0.63	0.87	9724.0**
Densities x (among selections)	38	4.57*	0.48*	1.55	5.04	2066.9**
Densities x {0 vs (1&2&3&4)}	2	0.85	1.23*	0.08	9.84	1111.2
Linear	1	0.92	2.16**	0.02	4.24	1792.2
Quadratic	1	0.78	0.29	0.13	15.44	429.4
Densities x {(1&2) vs (3&4)}	2	13.51*	0.14	4.50*	8.67	216.1
Linear	1	20.85**	0.33	5.44*	16.78	0.2
Quadratic	1	6.16	0.00	3.56	0.54	432.0
Densities x (1 vs 2)	2	0.32	0.68	0.08	4.12	539.9
Linear	1	0.61	1.25*	0.16	0.03	1008.0
Quadratic	1	0.02	0.08	0.00	8.20	71.8
Densities x (3 vs 4)	2	4.50	0.35	0.33	4.35	5026.9*
Linear	1	1.16	0.06	0.56	8.41	5774.4*
Quadratic	1	7.84	0.64	0.19	0.29	4279.3
Densities x among 0	2	2.18	0.82	0.99	2.75	612.7
Linear	1	0.04	1.02	0.36	0.18	123.2
Quadratic	1	4.32	0.61	1.61	5.31	1102.1
Densities x among 1	8	1.98	0.23	1.58	3.95	2212.8
Linear	4	2.81	0.28	1.91	0.33	3226.0*
Quadratic	4	1.15	0.18	1.25	7.56	1199.5

Table 57 (Continued)

Source of variations	Degrees of freedom	Mean squares				
		Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Densities x among 2	6	3.59	0.76*	1.96	6.60	3497.0*
Linear	3	2.51	0.91*	1.30	11.43*	5501.3**
Quadratic	3	4.67	0.61	2.61	1.43	1492.6
Densities x among 3	8	0.38	0.27	0.43	4.45	1629.8
Linear	4	0.57	0.30	0.40	2.31	2396.7
Quadratic	4	0.20	0.24	0.46	6.60	863.0
Densities x among 4	6	15.09**	0.53	3.19*	4.20	1967.8
Linear	3	22.06**	0.82*	4.33*	2.20	3608.0
Quadratic	3	8.11*	0.24	2.05	6.24	327.7
Densities x (among checks)	4	0.58	0.24	0.77	5.96	178.9
Densities x {(M14&C103)vs(M14xC103)}	2	0.27	0.44	1.33	3.23	2075.8
Linear	1	0.40	0.01	0.96	5.29	2575.5
Quadratic	1	0.13	0.87	1.69	1.18	1576.1
Densities x (M14 vs C103)	2	0.89	0.04	0.21	8.69	1501.9
Linear	1	1.69	0.00	0.25	8.29	2106.8
Quadratic	1	0.08	0.08	0.16	9.09	897.1
Error	264	2.84	0.29	1.13	4.90	1170.0
Total	344					
c.v. %		8.23	1.43	12.54	5.88	10.89

Source of variations	Degrees of freedom	Date silking	Date shedding	(Silking date-shedding date) +10
Replications	4	20.61**	40.83**	3.73**
Densities	2	5.96**	0.21	8.41**
Replications x densities	8	0.13	0.22	0.27
Entries	22	2.91**	3.80**	1.41**
Selections vs checks	1	2.18**	6.05**	0.95

Table 57 (Continued)

Source of variations	Degrees of freedom		Mean squares: Date silking	Mean squares: Date shedding	Mean squares: Silking date-shedding date) +10
Among selections[b]	19		2.65**	3.88**	1.48**
Group 0 vs (1&2&3&4)		1	4.82**	1.73*	0.61
(1&2) vs (3&4)		1	0.46	1.07	0.13
1 vs 2		1	3.52**	6.32**	0.45
3 vs 4		1	2.14**	0.12	3.14**
Among 0		1	0.03	0.81	0.96
Among 1		4	2.76**	6.23**	1.06**
Among 2		3	0.90**	2.41**	1.19**
Among 3		4	6.33**	6.81**	2.76**
Among 4		3	0.08	1.43**	1.30**
Among checks	2		5.78**	1.95**	1.02*
(M14&C103) vs (M14xC103)		1	0.88*	0.38	0.11
M14 vs C103		1	10.67**	3.53**	1.93**
Densities x entries	44		0.30	0.46*	0.21
Densities x (sel vs ch)	2		0.06	0.05	0.14
Linear		1	0.11	0.03	0.26
Quadratic		1	0.01	0.07	0.02
Densities x (among selections)	38		0.31*	0.52*	0.18
Densities x {0 vs (1&2&3&4)}	2		0.98*	1.36*	0.07
Linear		1	1.82**	2.60**	0.14
Quadratic		1	0.13	0.12	0.00
Densities x {(1&2) vs (3&4)}	2		0.19	0.39	0.09
Linear		1	0.25	0.75	0.16
Quadratic		1	0.13	0.03	0.02
Densities x (1 vs 2)	2		0.24	0.65	0.08
Linear		1	0.00	0.01	0.01
Quadratic		1	0.47	1.30*	0.16
Densities x (3 vs 4)	2		0.90*	0.30	0.22
Linear		1	1.05*	0.21	0.37
Quadratic		1	0.76	0.39	0.05

Table 57 (Continued)

Source of variations	Degrees of freedom		Mean squares Date silking	Date shedding	(Silking date-shedding date) +10
Densities x among 0	2		0.13	0.01	0.06
Linear		1	0.25	0.01	0.09
Quadratic		1	0.00	0.00	0.03
Densities x among 1	8		0.23	0.21	0.07
Linear		4	0.07	0.06	0.03
Quadratic		4	0.39	0.37	0.10
Densities x among 2	6		0.17	0.65	0.58
Linear		3	0.26	0.34	0.60
Quadratic		3	0.07	0.96*	0.56
Densities x among 3	8		0.26	0.30	0.05
Linear		4	0.33	0.36	0.07
Quadratic		4	0.19	0.24	0.03
Densities x among 4	6		0.34	1.05**	0.27
Linear		3	0.61*	2.00**	0.49
Quadratic		3	0.08	0.20	0.05
Densities x (among checks)	4		0.23	0.14	0.50
Densities x {(M14&C103)vs(M14xC103)}	2		0.38	0.25	0.81
Linear		1	0.21	0.21	0.00
Quadratic		1	0.54	0.28	1.60*
Densities x (M14 vs C103)	2		0.09	0.03	0.20
Linear		1	0.16	0.04	0.36
Quadratic		1	0.01	0.01	0.05
Error	264		0.21	0.31	0.28
Total	344				
c.v. %			4.10	5.32	10.08

Table 58. Analyses of variance for 10 plant and ear characters in testcrosses of 20 selected inbred lines and three checks evaluated at Kanawha, 1967

Source of variations	Degrees of freedom	Mean squares: Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Replications	4	5262.1*	1.80	848.81*	13.69	20.94
Densities	2	31460.0**	5.12*	140.84	4.63	118.03**
Replications x densities	8	1197.4	0.81	143.77	28.40	6.15
Entries	22	577.3**	0.69**	45.83**	21.73**	3.74**
Selections vs checks	1	863.2**	0.80	9.45	0.16	7.04**
Among selections[b]	19	456.7**	0.64**	36.39*	20.65**	3.79**
Group 0 vs (1&2&3&4)	1	700.9	0.91*	4.74	13.32	0.30
(1&2) vs (3&4)	1	71.2	0.02	0.58	0.00	19.44**
1 vs 2	1	57.0	0.16	13.49	53.77*	0.05
3 vs 4	1	1581.1**	0.65	109.35*	20.73	0.42
Among 0	1	80.7	0.03	4.86	1.31	0.02
Among 1	4	367.8*	0.35	24.67	10.46	3.85**
Among 2	3	206.3	0.14	11.00	3.44	0.55
Among 3	4	112.3	0.14	90.38**	40.53**	1.67
Among 4	3	1348.9**	2.68**	15.71	29.66*	9.35**
Among checks	2	1579.9**	1.14**	153.68**	42.72*	1.66
(M14&C103) vs (M14 x C103)	1	621.9*	0.57	96.14*	41.71*	2.61
M14 vs C103	1	2537.9**	1.71**	211.23**	43.73*	0.71
Densities x entries	44	105.2	0.32	32.29	11.49	1.25*
Densities x (sel vs ch)	2	193.8	0.31	67.74	33.81*	1.23
Linear	1	6.7	0.04	11.71	0.98	0.02
Quadratic	1	47.5	0.22	0.52	1.02	1.26

[a]Observed values were multiplied by 10^2.

[b]Orthogonal comparisons based on breeding groups.

Table 58 (Continued)

Sources of variations	Degrees of freedom		Mean squares				
			Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x (among selections)	38		98.7	0.32*	33.91*	12.19	1.07
Densities x {0 vs (1&2&3&4)}	2		193.9	0.31	87.74*	33.81*	1.23
Linear		1	135.2	0.28	14.16	17.78	1.93
Quadratic		1	252.5	0.34	161.32**	49.84*	0.53
Densities x {(1&2) vs (3&4)}	2		23.7	0.09	13.21	0.27	0.22
Linear		1	43.6	0.16	12.48	0.36	0.35
Quadratic		1	3.7	0.02	13.94	0.07	0.08
Densities x (1 vs 2)	2		4.2	0.00	4.54	4.17	0.01
Linear		1	1.7	0.00	7.51	7.63	0.00
Quadratic		1	6.5	0.00	1.57	0.71	0.00
Densities x (3 vs 4)	2		72.4	0.53	21.69	11.50	2.91*
Linear		1	27.1	0.66	14.56	2.95	2.26
Quadratic		1	117.6	0.39	29.21	19.15	3.56
Densities x among 0	2		50.3	0.05	23.22	2.43	0.01
Linear		1	82.8	0.04	39.69	3.24	0.00
Quadratic		1	17.8	0.05	6.75	1.61	0.01
Densities x among 1	8		101.2	0.22	51.76*	15.47	0.79
Linear		4	289.6*	0.25	31.87	8.93	0.96
Quadratic		4	15.2	0.01	21.38	13.40	0.30
Densities x among 2	6		145.4	1.13**	7.33	11.05	2.89**
Linear		3	47.1	1.35**	1.98	6.59	2.53*
Quadratic		3	243.7	0.91**	12.68	15.54	3.25**
Densities x among 3	8		152.4	0.13	26.63	11.17	0.63
Linear		4	289.6*	0.25	31.87	8.92	0.96
Quadratic		4	15.2	0.01	21.38	13.40	0.30
Densities x among 4	6		145.4	1.13**	7.33	11.05	2.89**
Linear		3	47.1	1.35**	1.98	6.57	2.53*
Quadratic		3	244.0	0.91**	12.68	15.54	3.25**

Table 58 (Continued)

Source of variations	Degrees of freedom	Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x (among checks)	4	206.1	0.41	30.05	10.09	3.15**
Densities x {(M14&C103)vs(M14xC103)}	2	212.7	0.40	2.78	8.60	2.58*
Linear	1	270.8	0.40	0.56	11.60	2.80
Quadratic	1	154.6	0.40	4.99	5.60	2.35
Densities x (M14 vs C103)	2	199.6	0.41	57.33	11.58	3.73*
Linear	1	299.3	0.25	32.49	4.41	5.57**
Quadratic	1	99.8	0.56	82.16	18.75	1.89
Error	264	113.2	0.21	22.35	9.39	0.82
Total	344					
c.v. %		14.39	10.85	5.12	7.44	11.75

Source of variations	Degrees of freedom	Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Replications	4	99.50	1.24	14.96	134.98**	46156.5
Densities	2	384.04**	4.38	71.10**	814.87**	211423.2**
Replications x densities	8	33.20	2.02	6.52	13.99	12400.5
Entries	22	25.08**	7.10**	8.35**	66.99**	11160.3**
Selections vs checks	1	16.48	0.01	5.45	21.23*	28137.4**
Among selections[b]	19	23.11**	6.21**	7.99**	76.34**	9121.1**
Group 0 vs (1&2&3&4)	1	69.41**	8.19**	18.74**	429.66**	2310.5
(1&2) vs (3&4)	1	10.14	0.49	29.40	139.72**	5123.6
1 vs 2	1	0.10	6.22**	0.14	36.80**	531.2
3 vs 4	1	26.05*	7.27**	21.76**	223.98**	232.1
Among 0	1	0.33	0.14	0.03	19.37*	3389.1
Among 1	4	10.87	4.92**	3.61	31.90**	7035.5**

Table 58 (Continued)

Source of variations	Degrees of freedom	Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Among 2	3	15.32*	11.56**	6.93**	74.26**	4296.4*
Among 3	4	9.86	3.85**	6.38**	39.85**	4082.7*
Among 4	3	68.09**	8.66**	15.80**	30.74**	34784.3**
Among checks	2	48.09**	19.08**	13.21**	0.55	22044.2**
(M14&C103) vs (M14xC103)	1	25.44*	0.95	6.97**	0.03	6674.0*
M14 vs C103	1	70.73**	37.20**	19.44**	1.05	37414.4**
Densities x entries	44	6.83	0.64	1.35	7.06	1893.5
Densities x (sel vs ch)	2	12.07	1.42	1.86	8.20	1665.3
Linear	1	1.47	0.90	0.30	4.29	9.7
Quadratic	1	6.90	0.14	1.37	6.74	4059.2
Densities x (among selections)	38	7.10	0.69	1.42	7.51*	1826.9
Densities x{0 vs (1&2&3&4)}	2	12.07	1.42	1.86	8.20	1665.4
Linear	1	11.88	1.35	2.92	2.94	1687.4
Quadratic	1	12.25	1.49	0.79	13.47	1643.3
Densities x {(1&2) vs (3&4)}	2	1.31	0.87	0.18	7.48	2982.3
Linear	1	2.05	0.15	0.32	4.61	4462.2
Quadratic	1	0.56	1.59	0.03	10.35	1502.3
Densities x (1 vs 2)	2	0.32	0.30	1.01	18.76*	1153.9
Linear	1	0.61	0.12	1.97	21.02*	323.8
Quadratic	1	0.03	0.47	0.04	16.49	1984.0
Densities x (3 vs 4)	2	8.60	0.62	1.05	4.72	2862.9
Linear	1	8.59	0.40	0.13	2.68	368.4
Quadratic	1	8.60	0.83	1.96	6.76	5357.4
Densities x among 0	2	0.01	0.56	0.33	3.77	157.7
Linear	1	0.00	1.04	0.25	6.76	198.8
Quadratic	1	0.01	0.08	0.40	0.77	116.6
Densities x among 1	8	6.43	0.72	1.16	4.10	1863.1
Linear	4	6.42	0.67	1.99	12.29*	2985.3
Quadratic	4	3.34	1.16*	1.36	3.67	832.1

Table 58 (Continued)

Source of variations	Degrees of freedom	Mean squares Ear diameter[a]	Shelling percent	Kernel depth	300-kernel weight	No. seeds per plant
Densities x among 2	6	20.50*	0.66	3.40**	9.22	3343.9
Linear	3	21.14**	1.19	3.63*	12.15	3412.4
Quadratic	3	19.86**	0.13	3.17*	6.28	3275.5
Densities x among 3	8	4.88	0.92	1.68	7.98	1492.7
Linear	4	6.41	0.65	2.00	12.29*	2153.2
Quadratic	4	3.34	1.16*	1.33	3.67	832.0
Densities x among 4	6	20.50*	0.66	3.40**	9.22	3343.9
Linear	3	21.14**	1.20	3.63*	12.12	3412.4
Quadratic	3	19.86**	0.13	3.16*	6.28	3275.5
Densities x (among checks)	4	5.60	0.20	0.93	3.59	2455.7
Densities x {(M14&C103)vs(M14xC103)}	2	6.27	0.18	1.67	1.79	2065.5
Linear	1	1.20	0.19	1.47	2.03	1713.6
Quadratic	1	11.33	0.16	1.87	1.55	2417.4
Densities x (M14 vs C103)	2	4.93	0.22	0.18	5.39	2845.9
Linear	1	5.29	0.13	0.09	9.42	5055.2
Quadratic	1	4.56	0.31	0.27	1.35	636.5
Error	264	4.81	0.48	1.12	4.83	1621.2
Total	344					
c.v. %		10.91	1.94	14.06	6.29	14.36

Table 59. Analyses of variance for 13 plant and ear characters in testcrosses of 20 selected inbred lines and three checks evaluated at Ames, 1967

Source of variations	Degrees of freedom			Mean squares				
				Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Replications	4			925.0	0.15	43.28	49.03	3.59
Densities	2			54746.8**	9.71**	12.32	42.27	176.30**
Replications x densities	8			1990.5	0.10	39.50	20.38	3.93
Entries	22			377.4**	0.62**	103.10**	54.34**	3.04**
Selections vs checks		1		808.4**	0.53	58.23*	0.54	2.23
Among selections[b]		19		376.5**	0.64**	66.71**	48.28**	3.18**
Group 0 vs (1&2&3&4)			1	944.6**	1.56**	13.38	16.92	0.02
(1&2) vs (3&4)			1	136.3	0.24	0.33	29.93	14.89**
1 vs 2			1	242.8	0.28	40.23	33.35**	0.73
3 vs 4			1	162.9	0.57	159.85**	43.24*	0.32
Among 0			1	18.0	0.06	9.63	1.93	4.37*
Among 1			4	65.4	0.09	38.22*	82.87**	1.98*
Among 2			3	361.8**	0.55*	8.50	10.76	2.27*
Among 3			4	406.4**	0.38	167.20**	78.47**	2.65**
Among 4			3	892.5**	0.20**	65.63**	38.13**	4.96**
Among checks		2		170.1	0.49	471.20**	138.78**	2.04*
(M14&C103) vs (M14 x C103)			1	338.0	0.80*	4.91	10.89	2.54
M14 vs C103			1	2.2	0.17	937.50**	266.67**	1.54
Densities x entries	44			129.5	0.22	7.33	5.07	0.98*
Densities x (sel vs ch)		2		25.1	0.12	8.20	10.59	0.40
Linear			1	7.0	0.10	10.64	1.60	0.72
Quadratic			1	43.1	0.13	5.75	19.65	0.07

[a]Observed values were multiplied by 10^2.

[b]Orthogonal comparisons based on breeding groups.

Table 59 (Continued)

Source of variations	Degrees of freedom		Mean squares				
			Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x (among selections)	38		142.7*	0.23	7.50	4.24	1.04*
Densities x {0 vs (1&2&3&4)}	2		231.0	0.26	0.44	0.72	2.83*
Linear		1	59.5	0.51	0.88	0.22	5.34**
Quadratic		1	402.4*	0.00	0.00	1.23	0.32
Densities x {(1&2) vs (3&4)}	2		3.7	0.09	8.65	1.34	0.27
Linear		1	2.2	0.16	10.24	2.56	0.14
Quadratic		1	5.3	0.01	7.05	0.12	0.04
Densities x (1 vs 2)	2		59.2	0.30	1.49	1.08	0.37
Linear		1	99.4	0.35	1.79	0.05	0.25
Quadratic		1	19.1	0.25	1.19	2.10	0.49
Densities x (3 vs 4)	2		107.9	0.24	1.08	1.41	0.90
Linear		1	104.1	0.39	1.20	0.46	1.61
Quadratic		1	111.6	0.08	0.95	2.28	0.18
Densities x among 0	2		142.8	0.08	2.81	8.83	0.20
Linear		1	282.2	0.16	0.01	4.00	0.10
Quadratic		1	3.4	0.00	5.60	13.65	0.29
Densities x among 1	8		124.6	0.13	7.37	4.85	0.75
Linear		4	120.0	0.18	10.43	6.24	0.83
Quadratic		4	129.2	0.08	4.30	3.46	0.67
Densities x among 2	6		180.0	0.34	4.28	2.82	1.50*
Linear		3	16.2	0.36	5.54	0.27	0.50
Quadratic		3	343.4*	0.30	3.02	5.37	2.54**
Densities x among 3	8		124.6	0.20	14.11	4.79	0.53
Linear		4	84.4	0.23	12.45	5.93	0.60
Quadratic		4	172.6	0.16	15.76	3.65	0.47
Densities x among 4	6		205.1*	0.40*	9.76	6.75	1.94**
Linear		3	210.6	0.70**	4.25	1.21	3.51**
Quadratic		3	199.5	0.10	15.27	12.28	0.37

Table 59 (Continued)

Source of variations	Degrees of freedom	Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x (among checks)	4	56.1	0.14	5.26	10.18	0.66
Densities x {(M14&C103)vs(M14xC103)}	2	65.0	0.25	0.32	12.33	0.58
Linear	1	6.8	0.48	0.56	24.65	0.09
Quadratic	1	123.2	0.02	0.05	0.00	1.07
Densities x (M14 vs C103)	2	47.2	0.03	10.22	8.03	0.74
Linear	1	76.0	0.04	1.69	9.00	1.12
Quadratic	1	18.8	0.01	18.75	7.05	0.36
Error	264	91.6	0.17	11.51	7.72	0.65
Total	344					
c.v. %		12.57	10.02	3.59	6.62	10.74

Source of variations	Degrees of freedom	Ear diameter[a]	Shelling percent	Kernel depth	300-kernel weight	No. seeds per plant
Replications	4	9.47	0.45	6.17	67.97	5467.8
Densities	2	596.02**	2.49	119.00**	1164.72	402079.8**
Replications x densities	8	9.77	0.61	2.35	103.03	6248.8
Entries	22	16.92**	2.38**	5.45**	50.51**	8110.2**
Selections vs checks	1	8.50	1.39	5.31*	5.16	17167.1**
Among selections[b]	19	18.48**	2.22**	5.72**	49.83**	7981.2**
Group 0 vs (1&2&3&4)	1	68.84**	1.25	21.84**	202.52**	74.7
(1&2) vs (3&4)	1	1.01	0.16	0.24	89.86**	798.1
1 vs 2	1	11.62	4.25**	7.07	42.38*	10641.8*
3 vs 4	1	19.88**	4.27**	15.81**	100.71**	1011.4
Among 0	1	3.53	0.00	1.50	2.11	1255.7
Among 1	4	5.21	0.53	1.67	43.58*	4431.6*

Table 59 (Continued)

Source of variations	Degrees of freedom	Mean squares: Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Among 2	3	12.01*	4.04**	2.39	35.34**	8383.8**
Among 3	4	12.19*	0.19	3.32	39.14**	5093.9*
Among 4	3	46.85**	5.75**	11.71**	24.13	24869.2**
Among checks	2	6.33	4.37**	2.92	79.59**	4808.0
(M14&C103) vs (M14xC103)	1	6.24	0.04	2.00	18.24	1327.8
M14 vs C103	1	6.41	8.69**	3.84	140.94**	8288.2*
Densities x entries	44	0.48	0.63	1.18	9.82	2612.0*
Densities x (sel vs ch)	2	0.14	0.53	0.02	10.39	1261.2
Linear	1	0.17	1.06	0.04	18.88	1596.9
Quadratic	1	0.11	0.00	0.00	1.91	925.5
Densities x (among selections)	38	5.51*	0.69**	1.46	10.35	2889.8*
Densities x {0 vs (1&2&3&4)}	2	4.33	1.17	1.03	13.40	3464.1
Linear	1	8.65	0.03	1.82	18.67	5094.0
Quadratic	1	0.00	2.31**	0.23	8.09	1834.1
Densities x {(1&2) vs (3&4)}	2	0.57	0.05	1.21	11.95	683.6
Linear	1	1.14	0.00	2.25	23.81	618.4
Quadratic	1	0.00	0.09	0.16	0.08	748.9
Densities x (1 vs 2)	2	4.46	0.08	1.71	3.81	2157.3
Linear	1	8.04	0.01	2.77	7.45	4156.2
Quadratic	1	0.87	0.15	0.65	0.16	158.4
Densities x (3 vs 4)	2	3.78	2.13**	2.19	18.87	6305.2*
Linear	1	7.11	3.51**	4.18	22.27	7389.3*
Quadratic	1	0.44	0.75	0.01	15.46	5221.0
Densities x among 0	2	1.85	0.21	0.54	26.91*	969.2
Linear	1	3.61	0.25	0.81	30.36*	734.4
Quadratic	1	0.08	0.17	0.27	23.46	1204.0
Densities x among 1	8	5.09	0.41	1.21	5.56	3059.0*
Linear	4	4.87	0.58	1.05	3.72	4799.9*
Quadratic	4	5.32	0.23	1.37	7.39	1317.9

Table 59 (Continued)

Source of variations	Degrees of freedom	Mean squares: Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Densities x among 2	6	6.47	0.20	2.19	12.20	3209.8*
Linear	3	2.50	0.15	1.83	8.13	212.5
Quadratic	3	10.11*	0.25	2.54	16.26	6207.1*
Densities x among 3	8	2.72	0.16	0.41	12.17	2059.6
Linear	4	2.71	0.30	0.26	22.01**	2328.7
Quadratic	4	2.70	0.03	0.57	2.34	1789.7
Densities x among 4	6	13.00**	2.18**	2.73	4.76	3741.2*
Linear	3	20.13**	1.79**	3.13*	8.20	3708.4*
Quadratic	3	5.87	2.57**	2.32	1.32	3774.0*
Densities x(among checks)	4	0.38	0.23	0.56	4.47	647.9
Densities x {(M14&C103)vs(M14xC103)}	2	0.72	0.40	1.04	5.65	140.5
Linear	1	1.33	0.24	2.62	0.79	58.1
Quadratic	1	0.11	0.57	0.18	10.50	223.0
Densities x (M14 vs C103)	2	0.05	0.05	0.08	3.30	1155.3
Linear	1	0.04	0.00	0.75	1.00	2265.8
Quadratic	1	0.05	0.10	0.00	5.60	44.9
Error	264	3.66	0.35	1.16	7.36	1723.6
Total	344					
c.v. %		9.59	1.62	12.83	7.81	14.27

Source of variations	Degrees of freedom	Date silking	Date shedding	(Silking date-shedding date) +10
Replications	4	0.22	1.40	1.16
Densities	2	30.06**	2.85*	15.52**
Replications x densities	8	0.72	0.38	1.39
Entries	22	2.09**	1.02**	0.62**
Selections vs checks	1	0.33	0.05	0.13

Table 59 (Continued)

Source of variations	Degrees of freedom		Mean squares		
			Date silking	Date shedding	(Silking date-shedding date) +10
Among selections[b]	19		1.84**	1.09**	0.50**
Group 0 vs (1&2&3&4)		1	8.46**	2.22**	2.02**
(1&2) vs (3&4)		1	2.32**	3.23**	0.07
1 vs 2		1	1.08	0.47	0.12
3 vs 4		1	4.82**	1.78**	0.74
Among 0		1	4.51**	0.81**	1.50*
Among 1		4	1.05*	0.61**	0.10
Among 2		3	0.24	0.51*	0.07
Among 3		4	1.78**	1.91**	0.31
Among 4		3	0.58	0.20	1.02**
Among checks	2		5.38**	0.78**	2.09**
(M14&C103) vs (M14xC103)		1	0.08	0.06	0.00
M14 vs C103		1	10.67**	1.50**	4.17**
Densities x entries	44		0.22	0.15	0.24
Densities x (sel vs ch)	2		0.20	0.13	0.18
Linear		1	0.01	0.24	0.14
Quadratic		1	0.38	0.02	0.23
Densities x (among selections)	38		0.23	0.16	0.23
Densities x {0 vs (1&2&3&4)}	2		0.10	0.13	0.17
Linear		1	0.00	0.24	0.24
Quadratic		1	0.21	0.02	0.11
Densities x {(1&2) vs (3&4)}	2		0.01	0.43	0.31
Linear		1	0.01	0.59	0.44
Quadratic		1	0.01	0.27	0.18
Densities x (1 vs 2)	2		0.15	0.15	0.18
Linear		1	0.20	0.22	0.00
Quadratic		1	0.10	0.08	0.36
Densities x (3 vs 4)	2		0.06	0.08	0.27
Linear		1	0.05	0.02	0.12
Quadratic		1	0.08	0.14	0.42

Table 59 (Continued)

Source of variations	Degrees of freedom		Mean squares Date silking	Date shedding	(Silking date-shedding date) +10
Densities x among 0	2		0.49	0.85**	0.14
Linear		1	0.81	1.69**	0.16
Quadratic		1	0.16	0.00	0.12
Densities x among 1	8		0.11	0.06	0.22
Linear		4	0.03	0.06	0.17
Quadratic		4	0.19	0.06	0.26
Densities x among 2	6		0.10	0.06	0.04
Linear		3	0.13	0.07	0.06
Quadratic		3	0.08	0.05	0.03
Densities x among 3	8		0.20	0.14	0.29
Linear		4	0.25	0.11	0.47
Quadratic		4	0.15	0.17	0.11
Densities x among 4	6		0.66	0.12	0.38
Linear		3	0.93*	0.20	0.30
Quadratic		3	0.40	0.04	0.46
Densities x (among checks)	4		0.13	0.08	0.34
Densities x {M14&C103)vs(M14xC103)}	2		0.02	0.02	0.04
Linear		1	0.03	0.01	0.08
Quadratic		1	0.01	0.02	0.00
Densities x (M14 vs C103)	2		0.25	0.14	0.65
Linear		1	0.49	0.16	1.21*
Quadratic		1	0.00	0.12	0.08
Error	264		0.33	0.15	0.25
Total	344				
c.v. %			4.03	2.82	10.35

Table 60. Analyses of variance for 10 plant and ear characters in testcrosses of 20 selected inbred lines and three checks evaluated at Kanawha, 1968

Source of variations	Degrees of freedom			Mean squares				
				Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Replications	4			173.9	0.16	104.92	119.57	1.24
Densities	2			30072.4**	0.62**	280.34	182.93*	80.79**
Replications x densities	8			119.5	0.05	69.94	39.87	0.34
Entries	22			605.1**	2.17**	109.31**	122.47**	4.98**
Selections vs checks		1		2763.4**	0.93**	2.51	56.91**	10.88**
Among selections[b]		19		258.9**	0.11**	82.41**	122.15**	4.31**
Group 0 vs (1&2&3&4)			1	64.6	0.07	2.14	170.92**	7.98**
(1&2) vs (3&4)			1	53.6	0.00	22.95	15.79	15.49**
1 vs 2			1	143.7	0.00	119.10**	293.34**	1.76
3 vs 4			1	531.6**	0.00	0.42	1.18	8.22**
Among 0			1	243.2**	0.03	3.84	29.93*	1.52
Among 1			4	622.2**	0.21**	79.96**	185.93**	6.70**
Among 2			3	69.4	0.12	12.68	9.98	1.86
Among 3			4	65.5	0.10	185.19**	163.62**	3.00**
Among 4			3	307.7**	0.13*	106.25**	129.20**	0.82
Among checks		2		2814.1**	0.88**	418.26**	155.30**	8.54**
(M14&C103) vs (M14 x C103)			1	418.6**	0.04	5.78	2.42	0.48
M14 vs C103			1	5209.7**	1.71**	830.73**	308.17**	16.60**
Densities x entries	44			63.7**	0.07	7.80	4.47	0.27
Densities x (sel vs ch)		2		155.7*	0.07	1.55	3.21	0.36
Linear			1	164.0*	0.00	2.41	0.39	0.45
Quadratic			1	147.4*	0.14	0.69	6.02	0.26

[a]Observed values were multiplied by 10^2.

[b]Orthogonal comparisons based on breeding groups.

Table 60 (Continued)

Source of variations	Degrees of freedom			Mean squares				
				Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x (among selections)	38			59.4*	0.05	8.72	4.65	0.26
Densities x {0 vs (1&2&3&4)}		2		170.0*	0.01	3.51	0.45	0.28
Linear			1	207.9*	0.01	1.50	0.86	0.46
Quadratic			1	132.0	0.00	5.52	0.03	0.10
Densities x {(1&2) vs (3&4)}		2		0.9	0.06	23.85*	1.74	0.16
Linear			1	0.0	0.03	0.75	1.96	0.07
Quadratic			1	1.7	0.08	46.94**	1.52	0.25
Densities x (1 vs 2)		2		21.6	0.02	11.91	2.69	0.36
Linear			1	12.2	0.04	7.34	0.94	0.39
Quadratic			1	30.9	0.00	16.47	4.43	0.33
Densities x (3 vs 4)		2		29.9	0.05	4.34	0.46	0.01
Linear			1	31.4	0.00	1.76	0.92	0.02
Quadratic			1	28.4	0.10	7.91	0.00	0.02
Densities x among 0		2		3.6	0.03	3.44	6.33	0.11
Linear			1	6.8	0.04	6.76	7.84	0.04
Quadratic			1	0.3	0.01	0.12	4.81	0.17
Densities x among 1		8		73.5	0.06	3.95	7.42	0.15
Linear			4	59.3	0.10	4.24	9.19	0.14
Quadratic			4	87.6*	0.01	3.68	5.64	0.17
Densities x among 2		6		88.0*	0.04	14.50	1.85	0.29
Linear			3	91.3	0.05	8.42	1.67	0.19
Quadratic			3	83.7	0.03	20.57*	2.03	0.38
Densities x among 3		8		57.7	0.04	11.12	7.81	0.32
Linear			4	73.8	0.03	9.98	6.56	0.23
Quadratic			4	41.7	0.05	12.27	9.06	0.41
Densities x among 4		6		38.2	0.06	4.96	3.39	0.43
Linear			3	29.0	0.03	9.80	5.71	0.62
Quadratic			3	47.5	0.09	0.12	1.07	0.23

Table 60 (Continued)

Source of variations	Degrees of freedom	Mean squares				
		Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x (among checks)	4	58.0	0.06	2.17	3.43	0.34
Densities x{(M14&C103)vs(M14xC103)}	2	24.1	0.03	2.66	4.85	0.06
Linear	1	41.8	0.00	0.03	0.08	0.06
Quadratic	1	6.4	0.05	5.29	9.61	0.05
Densities x (M14 vs C103)	2	91.7	0.09	1.60	2.00	0.62
Linear	1	25.0	0.01	2.25	3.61	0.59
Quadratic	1	158.4*	0.16	0.96	0.40	0.64
Error	264	35.8	0.05	7.17	4.23	0.32
Total	344					
c.v. %		7.61	5.10	2.62	4.56	7.25
		Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Replications	4	3.71	3.65*	1.39	16.88*	2039.6
Densities	2	193.92**	0.97	35.12**	741.00**	183761.7**
Replications x densities	8	3.04	0.89	0.49	4.32	1486.6
Entries	22	14.98**	3.72**	4.95**	72.55**	14573.1**
Selections vs checks	1	46.42**	4.23**	10.27**	9.66	26166.8**
Among selections[b]	19	8.43**	2.69**	3.84**	76.40**	9019.9**
Group 0 vs (1&2&3&4)	1	27.20**	0.02	7.26**	290.19**	22496.3**
(1&2) vs (3&4)	1	10.49**	0.74	5.84**	179.53**	6088.7**
1 vs 2	1	1.21	0.07	0.44	9.81	3117.1*
3 vs 4	1	0.06	0.97	1.62	87.20**	22731.9*
Among 0	1	1.93	1.69*	0.06	14.35*	5865.6**
Among 1	4	3.49*	2.26**	2.21**	46.55**	7829.0**

Table 60 (Continued)

Source of variations	Degrees of freedom	Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Among 2	3	10.38**	5.35**	4.24**	39.28**	3995.2**
Among 3	4	11.43**	1.40*	4.87**	101.15**	7066.1**
Among 4	3	9.48**	5.67**	6.23**	54.29**	13173.4**
Among checks	2	62.10**	13.19**	12.84**	67.44**	61532.1**
(M14&C103) vs (M14xC103)	1	1.39	2.46**	0.04	11.75	1909.6
M14 vs C103	1	121.50**	23.92**	25.63**	123.13**	121154.5**
Densities x entries	44	1.45	0.52*	0.69	4.82	969.0*
Densities x (sel vs ch)	2	3.69*	1.25*	1.35	3.43	2125.7*
Linear	1	0.05	1.22	0.19	0.29	835.3
Quadratic	1	7.33*	1.27	2.50*	6.55	3416.1*
Densities x (among selections)	38	1.19	0.30	0.59	5.11	967.7*
Densities x {0 vs (1&2&3&4)}	2	0.39	0.43	0.13	3.86	1054.6
Linear	1	0.00	0.85	0.09	5.06	1790.2
Quadratic	1	0.77	0.00	0.17	2.64	318.8
Densities x {(1&2) vs (3&4)}	2	0.41	0.18	1.20	11.91	1023.5
Linear	1	0.28	0.02	0.32	22.44*	1992.1
Quadratic	1	0.53	0.33	2.08	1.37	54.9
Densities x (1 vs 2)	2	0.14	0.22	0.08	0.53	156.2
Linear	1	0.00	0.43	0.10	0.00	111.8
Quadratic	1	0.27	0.00	0.05	1.06	200.6
Densities x (3 vs 4)	2	2.51	0.07	1.30	0.40	387.5
Linear	1	0.80	0.03	2.53*	0.78	391.5
Quadratic	1	4.21	0.11	0.06	0.02	283.6
Densities x among 0	2	0.29	0.46	0.08	0.28	3.9
Linear	1	0.36	0.50	0.04	0.44	7.3
Quadratic	1	0.21	0.41	0.12	0.13	0.4
Densities x among 1	8	1.04	0.61	0.40	4.53	1669.1**
Linear	4	1.39	0.13	0.17	6.07	1474.1*
Quadratic	4	0.70	1.09*	0.62	2.98	1864.0*

Table 60 (Continued)

Source of variations	Degrees of freedom		Mean squares				
			Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Densities x among 2	6		1.43	0.10	0.39	10.95*	990.7
Linear		3	1.03	0.04	0.03	10.93*	1599.3*
Quadratic		3	1.82	0.16	0.76	10.97*	382.2
Densities x among 3	8		0.79	0.25	0.53	6.18*	1256.2*
Linear		4	0.79	0.06	0.82	11.76*	2050.0**
Quadratic		4	0.80	0.45	0.25	0.60	462.4
Densities x among 4	6		2.44	0.21	1.18	1.50	379.1
Linear		3	1.54	0.24	0.55	2.32	353.3
Quadratic		3	3.34	0.18	1.48	0.67	404.9
Densities x (among checks)	4		2.79	2.18**	1.34	2.77	403.8
Densities x {(M14&C103)vs(M14xC103)}	2		0.63	0.35	0.36	5.01	142.1
Linear		1	0.12	0.63	0.40	8.57	74.0
Quadratic		1	1.14	0.06	0.32	1.45	210.2
Densities x (M14 vs C103)	2		4.94*	4.02**	2.33*	0.53	665.3
Linear		1	4.00	7.90**	2.89*	0.01	20.2
Quadratic		1	5.88*	0.14	1.76	1.04	1310.4
Error	264		1.17	0.33	0.58	3.69	645.2
Total	344						
c.v. %			5.04	0.57	8.90	5.18	8.92

Table 61. Analyses of variance for 13 plant and ear characters in testcrosses of 20 selected inbred lines and three checks evaluated at Ames, 1968

Source of variations	Degrees of freedom	Mean squares				
		Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Replications	4	343.4	0.05	43.84	9.16	0.81
Densities	2	36981.2**	0.04	194.14*	202.65**	84.18**
Replications x densities	8	92.0	0.07	30.01	19.55	0.34
Entries	22	144.1**	0.09	103.38**	70.68**	3.23**
Selections vs checks	1	215.3*	0.01	30.34	4.86	1.74*
Among selections[b]	19	152.7**	0.10*	77.04**	70.00**	3.55**
Group 0 vs (1&2&3&4)	1	99.2	0.19	43.24*	64.48*	4.08**
(1&2) vs (3&4)	1	57.2	0.01	0.30	27.31	14.50**
1 vs 2	1	144.4	0.01	154.88**	62.02*	1.43*
3 vs 4	1	17.7	0.01	62.15*	35.57*	4.53**
Among 0	1	13.5	0.43**	3.23	16.01	0.20
Among 1	4	288.6**	0.09	38.26*	111.01**	4.50**
Among 2	3	57.0	0.00	15.43	18.15*	1.94**
Among 3	4	186.5**	0.18*	222.12**	95.00**	4.16**
Among 4	3	166.5*	0.05	37.34*	82.00**	0.71
Among checks	2	32.2	0.02	390.22**	110.15**	1.01*
(M14&C103) vs (M14 x C103)	1	65.7	0.02	18.81	4.30	0.01
M14 vs C103	1	0.7	0.01	761.63**	216.00**	2.00**
Densities x entries	44	63.0	0.06	10.34	6.12	0.31
Densities x (sel vs ch)	2	186.6*	0.24*	0.24	13.58	1.29**
Linear	1	324.9**	0.39*	0.00	10.52	2.11**
Quadratic	1	48.3	0.08	0.48	16.64	0.41

[a]Observed values were multiplied by 10^2.

[b]Orthogonal comparisons based on breeding groups.

Table 61 (Continued)

Source of variations	Degrees of freedom		Mean squares: Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x (among selections)	38		50.6	0.06	11.41	6.10	0.27
Densities x {0 vs (1&2&3&4)}	2		13.1	0.21*	13.79	1.71	0.15
Linear		1	3.8	0.34*	6.29	0.35	0.25
Quadratic		1	22.5	0.08	21.28	3.07	0.04
Densities x {(1&2) vs (3&4)}	2		21.5	0.03	2.57	0.38	0.14
Linear		1	18.5	0.02	5.14	0.75	0.02
Quadratic		1	24.5	0.04	0.00	0.00	0.26
Densities x (1 vs 2)	2		14.5	0.04	5.50	3.18	0.22
Linear		1	28.7	0.01	6.19	5.78	0.00
Quadratic		1	0.3	0.07	4.80	0.59	0.44
Densities x (3 vs 4)	2		4.2	0.00	10.24	7.38	0.05
Linear		1	0.0	0.00	6.56	2.09	0.00
Quadratic		1	8.4	0.00	13.92	12.68	0.09
Densities x among 0	2		13.0	0.09	35.45*	0.82	0.45
Linear		1	2.5	0.09	46.24*	0.00	0.45
Quadratic		1	23.5	0.08	24.65	1.61	0.44
Densities x among 1	8		54.5	0.11	7.63	6.40	0.59*
Linear		4	56.6	0.15*	7.31	3.38	0.95*
Quadratic		4	52.4	0.08	7.94	9.41	0.23
Densities x among 2	6		27.9	0.03	7.54	1.09	0.18
Linear		3	18.7	0.04	5.44	0.17	0.18
Quadratic		3	37.1	0.02	9.64	2.01	0.17
Densities x among 3	8		111.4*	0.02	13.93	8.66	0.25
Linear		4	204.9**	0.02	15.59	6.75	0.10
Quadratic		4	17.9	0.03	12.28	10.57	0.40
Densities x among 4	6		49.0	0.02	13.48	13.08	0.14
Linear		3	79.2	0.02	21.90	23.75*	0.12
Quadratic		3	78.8	0.01	5.06	2.40	0.15

Table 61 (Continued)

Source of variations	Degrees of freedom	Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x (among checks)	4	122.7*	0.01	5.18	2.60	0.14
Densities x {(M14&C103)vs(M14xC103)}	2	142.8	0.02	2.63	2.06	0.27
Linear	1	181.0	0.03	4.81	0.75	0.63
Quadratic	1	104.7	0.01	0.44	3.36	0.01
Densities x (M14 vs C103)	2	102.5	0.01	7.73	3.14	0.02
Linear	1	151.3	0.01	9.00	1.21	0.00
Quadratic	1	53.8	0.00	6.45	5.07	0.02
Error	264	48.0	0.06	10.10	6.07	0.27
Total	344					
c.v. %		8.49	5.70	3.36	5.98	6.32

Source of variations	Degrees of freedom	Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Replications	4	1.32	0.54	1.04**	140.27*	1094.4
Densities	2	123.29**	0.14	26.37**	1221.58**	187282.4**
Replications x densities	8	1.26	0.30	0.06	25.79	941.6
Entries	22	4.74**	2.65**	4.49**	120.28**	6687.1**
Selections vs checks	1	0.03	4.84**	0.13	102.69**	16907.4**
Among selections[b]	19	5.18*	2.42**	4.95**	126.79**	6468.1**
Group 0 vs (1&2&3&4)	1	11.38**	0.34	3.62**	298.79**	31446.3*
(1&2) vs (3&4)	1	16.45**	0.07	11.57**	11.89	2933.4*
1 vs 2	1	4.37	0.63	1.60	240.64**	5586.1**
3 vs 4	1	0.98	0.09	1.19	237.23**	10847.0**
Among 0	1	2.41	0.36	0.03	15.55	616.1
Among 1	1	5.81**	1.70**	4.95**	84.11**	1418.1

Table 61 (Continued)

Source of variations	Degrees of freedom			Mean squares				
				Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Among 2			3	6.13**	6.54**	8.16**	156.30**	6896.2**
Among 3			4	2.91	0.76	4.25**	166.84**	6885.8**
Among 4			3	3.20*	4.96**	4.92**	44.06**	5853.3**
Among checks		2		2.92	3.73**	2.34**	67.29**	3657.2**
(M14&C103) vs (M14xC103)			1	2.00	2.45**	2.00*	4.85	2151.7
M14 vs C103			1	3.84	5.01**	2.67*	129.74**	5162.7**
Densities x entries	44			1.45	0.34	0.79	7.00	778.3
Densities x (sel vs ch)		2		5.86**	0.37	0.23	25.97*	536.1
Linear			1	11.40**	0.01	3.99**	49.02**	69.2
Quadratic			1	0.31	0.73	0.46	2.91	1003.0
Densities x (among selections)		38		1.24	0.33	0.74	6.20	655.4
Densities x {0 vs (1&2&3&4)}			2	0.60	0.53	0.15	2.56	266.7
Linear			1	0.92	1.03	0.10	4.61	483.0
Quadratic			1	0.27	0.02	0.20	0.51	50.4
Densities x {(1&2) vs (3&4)}			2	0.22	0.52	0.69	12.13	269.0
Linear			1	0.13	0.93	1.28	24.08	289.0
Quadratic			1	0.31	0.11	0.09	0.18	249.0
Densities x (1 vs 2)			2	1.80	0.06	0.13	8.01	471.2
Linear			1	3.03	0.00	2.53*	8.67	40.0
Quadratic			1	0.56	0.11	0.10	7.34	902.4
Densities x (3 vs 4)			2	1.69	0.17	3.39**	1.26	45.1
Linear			1	2.24	0.24	5.78**	0.07	90.0
Quadratic			1	1.15	0.10	1.00	2.45	0.1
Densities x among 0			2	0.11	0.13	0.25	0.51	65.9
Linear			1	0.16	0.01	0.49	0.01	15.2
Quadratic			1	0.05	0.24	0.00	1.01	116.6
Densities x among 1			8	2.95	0.09	0.45	4.23	803.4
Linear			4	4.00*	0.16	0.72	3.42	775.8
Quadratic			4	1.92	0.02	0.20	5.03	831.1

Table 61 (Continued)

Source of variations	Degrees of freedom		Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Densities x among 2	6		0.73	0.14	0.41	2.68	450.8
Linear		3	0.51	0.10	0.41	4.60	585.0
Quadratic		3	0.94	0.17	0.42	0.79	316.6
Densities x among 3	8		0.57	0.77	0.46	9.39	1579.7*
Linear		4	0.67	1.16**	0.65	15.44	2431.4**
Quadratic		4	0.47	0.39	0.28	3.36	727.9
Densities x among 4	6		0.97	0.35	1.12*	10.27	150.0
Linear		3	1.83	0.50	1.51	19.50*	223.6
Quadratic		3	0.09	0.24	0.72	1.04	76.2
Densities x (among checks)	4		1.19	0.37	0.59	5.09	2066.5*
Densities x{(M14&C103)vs(M14xC103)}	2		2.01	0.37	0.06	1.05	157.5
Linear		1	3.20	0.00	0.03	0.47	2279.8
Quadratic		1	0.81	0.73	0.09	1.65	870.3
Densities x (M14 vs C103)	2		0.38	0.38	1.13	9.13	2557.9*
Linear		1	0.49	0.29	1.69	3.06	2088.5
Quadratic		1	0.27	0.46	0.56	15.19	3027.4*
Error	264		1.13	0.32	0.49	6.53	648.0
Total	344						
c.v. %			4.97	1.52	8.51	6.85	8.68

Source of variations	Degrees of freedom		Date silking	Date shedding	(Silking date-shedding date) +10
Replications	4		10.60**	9.37*	0.59
Densities	2		22.54**	2.85	13.25**
Replications x densities	8		1.43	1.43	0.86
Entries	22		1.95**	1.39**	0.47*
Selections vs checks		1	0.09	0.43	0.14

Table 61 (Continued)

Source of variations	Degrees of freedom		Mean squares		
			Date silking	Date shedding	(Silking date-shedding date) +10
Among selections[b]	19		1.27**	1.15**	0.42*
Group 0 vs (1&2&3&4)		1	5.72**	1.97**	1.01*
(1&2) vs (3&4)		1	0.13	0.81*	1.71*
1 vs 2		1	0.14	0.95*	0.35
3 vs 4		1	4.82**	1.97**	0.53
Among 0		1	0.54	0.24	1.50*
Among 1		4	0.65	1.23**	0.34
Among 2		3	0.40	0.80**	0.16
Among 3		4	1.48**	1.36**	0.11
Among 4		3	1.03*	1.07**	0.20
Among checks	2		9.37**	4.11**	1.15*
(M14&C103) vs (M14xC103)		1	0.02	0.06	0.14
M14 vs C103		1	18.73**	8.17**	2.16**
Densities x entries	44		0.21	0.14	0.25
Densities x (sel vs ch)	2		0.07	0.07	0.14
Linear		1	0.14	0.00	0.15
Quadratic		1	0.00	0.13	0.13
Densities x (among selections)	38		0.23	0.14	0.25
Densities x {0 vs (1&2&3&4)}	2		0.20	0.11	0.06
Linear		1	0.04	0.14	0.03
Quadratic		1	0.36	0.09	0.10
Densities x {(1&2) vs (3&4)}	2		0.01	0.02	0.10
Linear		1	0.00	0.02	0.07
Quadratic		1	0.04	0.01	0.12
Densities x (1 vs 2)	2		0.03	0.05	0.09
Linear		1	0.01	0.08	0.04
Quadratic		1	0.16	0.01	0.13
Densities x (3 vs 4)	2		0.34	0.29	0.01
Linear		1	0.01	0.02	0.00
Quadratic		1	0.68	0.55	0.02

Table 61 (Continued)

Source of variations	Degrees of freedom	Mean squares: Date silking	Date shedding	(Silking date-shedding date) +10
Densities x among 0	2	0.14	0.02	0.06
Linear	1	0.16	0.01	0.09
Quadratic	1	0.12	0.03	0.03
Densities x among 1	8	0.24	0.11	0.22
Linear	4	0.26	0.14	0.25
Quadratic	4	0.23	0.07	0.19
Densities x among 2	6	0.10	0.12	0.05
Linear	3	0.12	0.22	0.06
Quadratic	3	0.07	0.01	0.04
Densities x among 3	8	0.49	0.20	0.64*
Linear	4	0.82*	0.30	1.02**
Quadratic	4	0.16	0.11	0.26
Densities x among 4	6	0.12	0.16	0.31
Linear	3	0.23	0.27	0.58
Quadratic	3	0.01	0.06	0.38
Densities x (among checks)	4	0.11	0.22	0.28
Densities x {(M14&C103)vs(M14xC103)}	2	0.19	0.24	0.39
Linear	1	0.33	0.08	0.08
Quadratic	1	0.04	0.40	0.69
Densities x (M14 vs C103)	2	0.03	0.20	0.18
Linear	1	0.04	0.01	0.09
Quadratic	1	0.01	0.40	0.27
Error	264	0.28	0.15	0.26
Total	344			
c.v. %		4.25	3.22	10.21

Table 62. Analyses of variance for 10 plant and ear characters in testcrosses of 20 selected inbred lines and three checks evaluated at Ankeny, 1968

Sources of variation	Degrees of freedom			Mean squares				
				Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Replications	4			523.0	0.13	133.56	45.93	0.62
Densities	2			48784.0**	3.01**	339.66*	86.60	165.94**
Replications x densities	8			228.6	0.15	61.77	29.80	1.06
Entries	22			319.6**	0.35**	94.21**	48.91**	3.00**
Selections vs checks		1		63.2	0.73**	0.27	16.91	7.56**
Among selections[b]		19		346.5**	0.35**	62.37**	44.91**	3.02**
Group 0 vs (1&2&3&4)			1	4.8	0.44*	94.62*	51.15*	0.31
(1&2) vs (3&4)			1	134.4	0.21	0.91	3.23	4.54**
1 vs 2			1	194.9*	0.27	19.29	55.68*	6.50**
3 vs 4			1	348.2**	0.22	15.67	7.35	0.03
Among 0			1	112.7	0.00	112.67*	10.14	0.10
Among 1			4	551.6**	0.18	81.43**	74.82**	5.30**
Among 2			3	73.9	0.11	21.24	1.79	2.43**
Among 3			4	297.5**	0.17	98.44**	44.28*	2.77**
Among 4			3	723.7**	1.28**	52.92*	81.32**	2.10**
Among checks		2		191.9*	0.12	443.61**	102.88**	0.58
(M14&C103) vs (M14 x C103)			1	3.0	0.06	18.40	3.92	0.01
M14 vs C103			1	380.8**	0.17	868.81**	201.84**	1.14
Densities x entries	44			46.2	0.17**	24.69	11.35	0.65**
Densities x (sel vs ch)		2		4.1	0.14	1.65	23.32	0.15
Linear			1	4.6	0.26	2.30	43.73	0.29
Quadratic			1	3.5	0.02	1.00	2.92	0.01

[a]Observed values were multiplied by 10^2.

[b]Orthogonal comparisons based on breeding groups.

Table 62 (Continued)

Source of variations	Degrees of freedom		Mean squares				
			Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x (among selections)	38		49.6	0.19**	27.30	10.53	0.73**
Densities x {0 vs (1&2&3&4)}	2		134.5	0.12	195.56**	25.19	1.03
Linear		1	266.3*	0.20	391.04**	32.28	2.04*
Quadratic		1	2.7	0.03	0.17	18.10	0.02
Densities x {(1&2) vs (3&4)}	2		35.2	0.20	16.15	1.14	1.00
Linear		1	24.7	0.36	3.87	1.07	1.87*
Quadratic		1	45.6	0.04	28.41	1.20	0.15
Densities x (1 vs 2)	2		105.3	0.17	27.93	36.73	0.91
Linear		1	10.5	0.20	6.19	27.34	1.05
Quadratic		1	200.6*	0.11	49.67	46.13	0.76
Densities x (3 vs 4)	2		0.4	0.21	23.35	4.36	0.54
Linear		1	0.2	0.40*	19.88	0.40	1.02
Quadratic		1	0.5	0.02	26.82	8.32	0.04
Densities x among 0	2		15.5	0.00	57.29	8.24	0.03
Linear		1	0.8	0.00	79.21	16.00	0.04
Quadratic		1	30.1	0.00	35.36	0.48	0.01
Densities x among 1	8		48.2	0.08	12.68	13.92	0.18
Linear		4	25.5	0.05	20.31	8.96	0.12
Quadratic		4	70.9	0.12	5.06	18.89	0.25
Densities x among 2	6		55.8	0.07	13.95	9.07	0.61
Linear		3	13.7	0.11	16.01	14.33	0.62
Quadratic		3	98.0	0.02	11.89	3.47	0.60
Densities x among 3	8		37.4	0.10	13.06	7.26	0.45
Linear		4	36.3	0.11	19.65	7.43	0.47
Quadratic		4	38.5	0.09	6.47	7.10	0.44
Densities x among 4	6		46.9	0.07	17.85	4.19	2.00**
Linear		3	81.0	1.21**	13.84	2.12	3.56
Quadratic		3	12.7	0.15	21.85	6.25	0.38

Table 62 (Continued)

Source of variations	Degrees of freedom			Mean squares				
				Yield	No. ear per plant[a]	Plant height	Ear height	Ear length
Densities x (among checks)	4			38.0	0.06	11.41	13.08	0.18
Densities x {(M14&C103)vs(M14xC103)}		2		47.8	0.07	12.70	25.92	0.34
Linear			1	92.9	0.08	10.45	0.00	0.57
Quadratic			1	2.6	0.05	14.95	51.84	0.10
Densities x (M14 vs C103)		2		28.0	0.05	10.10	0.24	0.03
Linear			1	50.4	0.09	19.36	0.36	0.00
Quadratic			1	5.6	0.00	0.85	0.12	0.06
Error	264			46.7	0.09	22.33	12.71	0.37
Total	344							
c.v. %				10.84	7.10	4.68	7.78	8.15
				Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Replications	4			6.21	0.40	3.23	131.24**	1234.5
Densities	2			440.80**	7.99*	68.80**	675.51**	486137.2**
Replications x densities	8			6.14	1.02	1.74	9.15	3903.3
Entries	22			15.02**	2.44**	6.15**	115.39**	6261.6**
Selections vs checks		1		8.30	0.58	0.28	163.80**	16759.0**
Among selections[b]		19		16.16**	2.40**	6.95**	110.57**	6266.7**
Group 0 vs (1&2&3&4)			1	48.72**	0.18	6.36**	2.16	1.4
(1&2) vs (3&4)			1	37.50**	0.59	10.31**	25.16	8462.5**
1 vs 2			1	4.63	1.79	0.88	102.67**	17001.7**
3 vs 4			1	13.13*	0.01	15.40**	133.21**	333.9
Among 0			1	0.11	0.98	1.93	57.54**	183.7
Among 1			4	1.29	0.60	2.52**	156.97**	2938.4**

Table 62 (Continued)

Source of variations	Degrees of freedom				Mean squares				
					Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Among 2				3	15.33**	5.30**	11.98**	163.45**	5769.8**
Among 3				4	8.20**	1.15	2.62**	76.06**	3926.1**
Among 4				3	40.00**	6.37**	13.42**	119.23**	16105.6**
Among checks		2			7.24	3.72**	1.22	136.92**	964.5
(M14&C103) vs (M14xC103)				1	0.98	0.05	0.50	12.73	614.8
M14 vs C103				1	13.50*	7.39**	1.93	261.10**	1314.2
Densities x entries	44				3.52	0.49	0.72	13.96**	1530.0*
Densities x (sel vs ch)		2			4.55	0.20	0.30	10.60	659.2
Linear				1	9.00	0.05	0.03	18.06	1207.0
Quadratic				1	0.09	0.34	0.56	3.13	111.5
Densities x (among selections)		38			3.64*	0.52	0.73	15.27**	1368.1*
Densities x {0 vs (1&2&3&4)}			2		3.35	0.77	0.65	0.78	2378.9
Linear				1	6.62	1.26	1.27	1.36	4749.5**
Quadratic				1	0.08	0.27	0.02	0.19	8.3
Densities x {(1&2) vs (3&4)}			2		2.85	0.42	0.48	2.25	186.4
Linear				1	4.84	0.04	0.87	0.58	24.3
Quadratic				1	0.85	0.80	0.09	3.93	348.5
Densities x (1 vs 2)			2		4.42	0.64	0.62	16.83	2928.9*
Linear				1	6.29	0.90	0.11	31.38**	2125.8
Quadratic				1	2.54	0.33	1.13	2.28	3731.9*
Densities x (3 vs 4)			2		1.56	0.49	0.46	11.22	1095.0
Linear				1	2.95	0.73	0.90	14.11	1280.7
Quadratic				1	0.17	0.24	0.01	8.32	909.3
Densities x among 0			2		0.19	0.14	0.01	12.85	443.6
Linear				1	0.16	0.10	0.01	23.62	795.2
Quadratic				1	0.21	0.16	0.00	2.08	91.8
Densities x among 1			8		2.22	0.22	0.63	2.00	1859.6*
Linear				4	1.34	0.29	0.70	27.84**	2115.5*
Quadratic				4	3.10	0.14	0.55	12.01	1603.7

Table 62 (Continued)

Source of variations	Degrees of freedom	Mean squares				
		Ear diameter[a]	Shelling percent	Kernel depth[a]	300-kernel weight	No. seeds per plant
Densities x among 2	6	1.40	0.53	0.33	10.00	783.4
Linear	3	1.53	0.51	0.17	14.35	927.8
Quadratic	3	1.26	0.55	0.51	5.48	638.9
Densities x among 3	8	1.90	0.60	0.89	28.27**	2691.0**
Linear	4	1.14	0.18	1.37	55.66**	5197.4**
Quadratic	4	2.67	0.97	0.42	5.88	183.7
Densities x among 4	6	12.05**	0.84	1.58*	7.88	1672.0
Linear	3	21.66	1.35	1.45	14.54	2813.6*
Quadratic	3	3.44	0.41	1.70*	1.22	530.3
Densities x (among checks)	4	1.87	0.42	0.79	3.21	198.0
Densities x {(M14&C103)vs(M14xC103)}	2	2.41	0.15	0.41	5.22	235.4
Linear	1	4.81	0.01	0.56	10.42	461.3
Quadratic	1	0.00	0.29	0.25	0.01	9.4
Densities x (M14 vs C103)	2	1.34	0.70	1.17	1.19	158.5
Linear	1	2.56	1.04	2.25	2.28	84.6
Quadratic	1	0.12	0.35	0.08	0.10	232.3
Error	264	2.39	0.52	0.73	6.88	865.1
Total	344					
c.v. %		7.77	1.93	11.36	8.05	11.38

Table 63. Average plant height for 20 selected inbred lines and three checks in testcross performance, data summarized for three population levels over six environments

Entry no.	Plant height (cm) Low[b]	Med	High	Means	Regression coefficients[a] R_ℓ	R_q
HP group						
01	213	213	216	214	1.45	0.70
02	208	212	218	213	4.74	0.40
03	211	211	213	211	0.95	0.19
04	212	213	211	212	-0.27	-0.54
05	208	212	215	202	3.54	0.07
06	217	219	219	218	1.27	-0.50
07	216	215	218	217	1.07	0.61
08	208	209	212	210	1.75	0.44
09	201	202	203	202	0.97	-0.01
10	221	225	223	223	1.05	-1.21
$\bar{x}$	211	213	215	213	1.65	0.01
LP group						
11	214	213	208	212	-3.10	-0.52
12	210	207	212	210	1.10	1.29
13	208	212	212	211	2.33	-0.69
14	218	220	215	218	-1.54	-1.14
15	209	214	215	213	3.32	-0.60
16	208	210	208	209	0.52	-0.52
17	209	209	210	209	0.77	0.27
18	214	217	215	215	0.69	-0.69
19	211	213	216	213	2.33	0.08
20	215	218	222	218	3.72	0.12
$\bar{x}$	211	213	214	213	1.02	-0.24
Checks						
21	201	205	204	203	1.25	-0.67
22	225	223	225	224	0.25	0.55
23	214	216	216	215	0.87	-0.37

[a]Regression coefficients were calculated using more decimal places than given for the mean values presented for this table.

[b]Plant densities.

Table 64. Average ear height for 20 selected inbred lines and three checks in testcross performance, data summarized for three population levels over six environments

Entry no.	Ear height (cm) Low[b]	Med	High	Means	Regression coefficients[a] R_ℓ	R_q
HP group						
01	91	92	96	93	2.50	0.39
02	90	89	94	91	2.00	1.03
03	92	91	95	93	1.35	0.64
04	90	92	94	92	1.80	0.11
05	90	91	93	92	1.80	0.03
06	101	99	102	101	0.52	0.63
07	96	96	101	98	2.25	0.93
08	96	97	99	98	1.50	0.17
09	86	87	90	88	1.99	0.36
10	100	100	101	100	0.73	0.08
$\bar{x}$	93	93	96	94	1.65	0.44
LP group						
11	91	91	93	92	1.00	0.31
12	92	93	95	94	1.57	0.21
13	91	90	93	92	0.87	0.60
14	100	101	101	101	0.28	-0.16
15	94	96	100	97	2.94	0.21
16	87	88	88	88	0.44	-0.17
17	91	94	96	93	2.53	-0.09
18	99	100	102	100	1.52	0.19
19	93	96	95	95	0.77	-0.72
20	95	97	101	98	2.82	0.47
$\bar{x}$	93	95	96	95	1.48	0.09
Checks						
21	86	88	92	88	2.97	0.11
22	98	98	102	99	2.03	0.84
23	94	95	97	95	1.60	-0.02

[a]Regression coefficients were calculated using more decimal places than given for the mean values presented for this table.

[b]Plant densities.

Table 65. Average number of ears per plant for 20 selected inbred lines and three checks in testcross performance, data summarized for three population levels over six environments

Entry no.	No. ears/plant Low[b]	Med	High	Means	Regression coefficients[a] R_{ℓ}	R_q
HP group						
01	0.99	0.97	0.95	0.97	-0.020	0.000
02	1.01	1.00	0.97	0.99	-0.020	-0.003
03	0.99	0.97	0.95	0.97	-0.020	0.000
04	0.99	0.98	0.94	0.97	-0.025	-0.005
05	1.00	0.99	0.96	0.98	-0.020	-0.003
06	0.98	0.96	0.91	0.95	-0.035	-0.005
07	0.99	0.98	0.98	0.98	-0.005	-0.002
08	1.00	0.99	0.95	0.98	-0.025	-0.005
09	0.99	0.99	0.96	0.98	-0.015	-0.005
10	0.99	1.00	0.99	0.99	0.000	-0.003
$\bar{x}$	0.99	0.98	0.96	0.98	-0.915	-0.002
LP group						
11	0.96	0.97	0.90	0.94	-0.030	-0.013
12	0.98	0.99	0.92	0.96	-0.030	-0.013
13	0.99	0.96	0.88	0.94	-0.055	-0.008
14	0.98	0.97	0.91	0.95	-0.035	-0.008
15	0.96	0.97	0.90	0.94	-0.030	-0.013
16	0.96	0.92	0.73	0.87	-0.115	-0.025
17	0.98	0.99	0.90	0.96	-0.040	-0.017
18	0.98	0.96	0.91	0.95	-0.035	-0.005
19	0.98	0.97	0.90	0.95	-0.040	-0.010
20	0.96	0.97	0.89	0.94	-0.035	-0.015
$\bar{x}$	0.97	0.96	0.88	0.94	-0.045	-0.012
Checks						
21	0.98	0.98	0.93	0.96	-0.025	-0.008
22	0.92	0.94	0.85	0.90	-0.035	-0.018
23	0.96	0.95	0.89	0.93	-0.035	-0.008

[a]Regression coefficients were calculated using more decimal places than given for the mean values presented for this table.

[b]Plant densities.

Table 66. Average ear length for 20 selected inbred lines and three checks in testcross performance, data summarized for three population levels over six environments

Entry no.	Ear length (mm) Low[b]	Med	High	Mean	Regression coefficients[a] R_ℓ	R_q
HP group						
01	183	177	150	170	-16.6	-3.6
02	189	177	152	172	-18.4	-2.1
03	195	181	154	176	-20.6	-2.2
04	196	182	151	176	-22.4	-2.8
05	197	180	154	177	-21.6	-1.6
06	191	177	151	173	-19.9	-1.9
07	203	187	162	184	-20.2	-1.6
08	206	194	166	189	-19.9	-2.6
09	198	182	155	178	-21.6	-2.1
10	196	181	164	180	-15.8	-0.3
$\bar{x}$	195	182	156	178	-19.7	-2.1
LP group						
11	195	182	150	175	-22.5	-3.1
12	182	169	131	161	-25.6	-4.4
13	194	170	140	168	-27.2	-1.1
14	208	197	163	189	-22.6	-4.0
15	174	163	134	157	-20.0	-2.9
16	203	186	127	172	-37.8	-6.8
17	209	194	156	186	-26.4	-3.7
18	200	182	151	178	-24.6	-2.1
19	216	200	165	194	-25.7	-3.1
20	193	181	145	173	-24.4	-4.2
$\bar{x}$	197	182	146	175	-25.7	-3.5
Checks						
21	190	173	143	169	-23.7	-2.2
22	178	175	145	166	-16.5	-4.7
23	192	171	143	169	-24.5	-1.1

[a]Regression coefficients were calculated using more decimal places than given for the mean values presented for this table.

[b]Plant densities.

Table 67. Average ear diameter for 20 selected inbred lines and three checks in testcross performance, data summarized for three population levels over six environments

Entry no.	Ear diameter (mm) Low[b]	Med	High	Mean	Regression coefficients[a] R_ℓ	R_q
HP group						
01	51	49	44	48	-3.2	-0.6
02	51	50	46	49	-2.7	-0.3
03	50	49	44	48	-3.0	-0.4
04	50	49	43	47	-3.6	-0.8
05	50	47	43	48	-3.3	-0.2
06	49	46	41	47	-3.9	-0.3
07	50	48	45	47	-2.4	-0.1
08	50	47	43	47	-3.2	-0.2
09	49	47	43	46	-3.0	-0.4
10	51	49	46	49	-2.6	-0.5
$\bar{x}$	50	48	44	47	-3.1	-0.4
LP group						
11	48	46	40	44	-3.7	-0.6
12	51	50	43	46	-3.9	-0.9
13	49	46	41	45	-4.2	-0.4
14	48	47	42	46	-3.4	-0.7
15	50	49	44	47	-3.8	-0.6
16	47	44	32	41	-7.6	-1.5
17	47	46	39	44	-4.1	-1.0
18	49	46	41	45	-3.9	-0.5
19	48	45	40	44	-4.0	-0.5
20	47	47	39	45	-4.1	-1.2
$\bar{x}$	48	46	40	45	-4.2	-0.8
Checks						
21	50	48	43	47	-3.4	-0.6
22	45	44	38	42	-3.7	-1.0
23	49	46	40	45	-4.2	-0.5

[a]Regression coefficients were calculated using more decimal places than given for the mean values presented for this table.

[b]Plant densities.

Table 68. Average kernel depth for 20 selected inbred lines and three checks in testcross performance, data summarized for three population levels over six environments

Entry no.	Kernel depth (mm) Low[b]	Med	High	Mean	Regression coefficients[a] R_ℓ	R_q
HP group						
01	20	20	18	19	-1.4	-0.3
02	20	19	18	19	-1.1	0.0
03	20	18	17	18	-1.3	0.0
04	20	19	16	18	-1.8	-0.2
05	19	18	16	18	-1.5	0.0
06	21	19	17	19	-1.9	-0.1
07	20	20	18	19	-1.3	-0.2
08	19	17	16	17	-1.6	0.0
09	20	19	17	19	-1.3	-0.1
10	21	20	18	20	-1.2	-0.3
$\bar{x}$	20	19	17	19	-1.4	-0.1
LP group						
11	19	18	16	17	-1.6	-0.2
12	21	21	18	20	-1.7	-0.4
13	19	17	15	17	-1.6	-0.1
14	19	18	16	18	-1.4	-0.3
15	21	20	18	19	-1.4	-0.2
16	18	17	12	16	-3.2	-0.6
17	17	17	15	16	-1.5	-0.4
18	19	19	16	18	-1.7	-0.3
19	18	17	15	17	-1.1	-0.3
20	19	19	16	18	-1.7	-0.5
$\bar{x}$	19	18	16	18	-1.7	-0.3
Checks						
21	20	19	17	19	-1.5	-0.3
22	17	17	14	16	-1.6	-0.5
23	19	18	16	18	-1.5	-0.3

[a]Regression coefficients were calculated using more decimal places than given for the mean values presented for this table.

[b]Plant densities.

Table 69. Average shelling percentage for 20 selected inbred lines and three checks in testcross performance, data summarized for three population levels over six environments

Entry no.	Shelling percent Low[b]	Med	High	Mean	Regression coefficients[a] R_{ℓ}	R_q
HP group						
01	82.6	82.6	82.7	82.6	0.06	0.03
02	81.4	82.4	82.7	82.2	0.67	-0.12
03	82.8	82.9	82.6	82.8	-0.13	-0.07
04	82.8	83.4	82.6	82.9	-0.13	-0.21
05	82.7	82.6	82.4	82.6	-0.18	0.01
06	82.8	83.0	82.5	82.8	-0.13	-0.11
07	83.7	83.7	83.5	83.7	-0.11	-0.04
08	80.8	81.1	80.8	80.9	-0.01	-0.10
09	82.8	82.6	82.5	82.7	-0.16	0.01
10	81.8	82.1	82.5	82.2	0.43	0.05
$\bar{x}$	82.4	82.6	82.5	82.5	0.04	-0.06
LP group						
11	82.4	82.1	81.6	82.0	-0.42	-0.04
12	82.5	82.7	82.1	82.5	-0.21	-0.13
13	79.6	79.8	79.5	79.6	-0.05	-0.09
14	81.9	82.6	82.0	82.2	0.08	-0.22
15	81.6	81.6	81.2	81.5	-0.23	-0.07
16	81.7	81.8	79.6	81.0	-1.05	-0.38
17	81.2	81.6	81.5	81.5	0.15	-0.07
18	82.4	82.5	81.7	82.2	-0.33	-0.16
19	81.8	81.1	81.4	81.4	-0.21	0.17
20	81.8	81.5	81.4	81.4	-0.18	0.05
$\bar{x}$	81.7	81.7	81.2	81.5	-0.25	-0.10
Checks						
21	83.0	83.1	82.9	83.0	-0.06	-0.06
22	80.1	80.1	79.8	80.0	-0.20	-0.05
23	81.7	81.9	81.7	81.8	0.01	-0.05

[a]Regression coefficients were calculated using more decimal places than given for the mean values presented for this table.

[b]Plant densities.

Table 70. Average 300-kernel weight for 20 selected inbred lines and three checks in testcross performance, data summarized for three population levels over six environments

Entry no.	300-kernel weight (g) Low[b]	Med	High	Mean	Regression coefficients[a] R_ℓ	R_q
HP group						
01	91.5	87.6	78.1	85.7	-6.72	-0.95
02	90.4	84.7	78.4	84.5	-6.01	-0.10
03	82.5	79.0	70.7	77.4	-5.93	-0.80
04	80.0	75.0	67.9	74.3	-6.04	-0.43
05	78.9	70.6	65.9	71.8	-6.48	0.61
06	68.6	83.0	73.6	81.1	-6.51	-0.96
07	81.3	77.4	71.0	76.6	-5.18	-0.41
08	80.6	74.0	63.7	72.8	-8.42	-0.64
09	82.5	76.3	71.3	76.7	-5.59	0.19
10	96.5	87.8	77.4	87.2	-9.53	-0.28
$\bar{x}$	85.1	79.1	71.5	78.8	-6.79	-0.28
LP group						
11	80.1	73.7	68.0	74.0	-6.05	0.11
12	88.7	86.3	83.6	86.2	-2.59	-0.05
13	84.9	80.9	74.3	80.1	-5.28	-0.44
14	89.1	81.4	74.0	81.5	-7.53	0.05
15	77.4	74.8	68.2	73.5	-4.59	-0.68
16	85.8	81.7	74.8	80.8	-5.54	-0.47
17	86.4	80.3	72.3	79.7	-7.08	-0.30
18	85.9	80.1	71.8	79.3	-7.06	-0.42
19	90.5	82.3	73.8	82.2	-8.35	-0.07
20	91.4	88.7	82.9	87.6	-4.25	-0.53
$\bar{x}$	86.0	81.0	74.4	80.5	-5.83	-0.28
Checks						
21	81.9	77.8	72.1	77.3	-4.92	-0.27
22	92.1	86.1	79.9	85.4	-5.09	-0.38
23	85.2	80.6	75.8	80.5	-4.71	-0.05

[a]Regression coefficients were calculated using more decimal places than given for the mean values presented for this table.

[b]Plant densities.

Table 71. Average no. seeds per plant for 20 selected inbred lines and three checks in testcross performance, data summarized for three population levels over six environments

Entry no.	No. seeds per plant Low[b]	Med	High	Mean	Regression coefficients[a] R_ℓ	R_q
HP group						
01	697	650	512	620	-92.5	-15.4
02	681	639	522	614	-79.3	-12.6
03	781	705	565	683	-108.2	-10.6
04	818	752	582	717	-118.2	-17.2
05	801	724	562	696	-119.5	-14.0
06	739	657	542	646	-98.5	-5.4
07	814	722	608	715	-103.2	-3.6
08	793	738	602	711	-95.2	-13.6
09	748	608	629	652	-109.7	
10	674	650	588	638	-43.0	-6.4
$\bar{x}$	755	692	561	669	-96.7	-11.3
LP group						
11	779	726	550	685	-114.5	-20.2
12	716	644	427	596	-144.6	-24.0
13	735	640	489	621	-122.9	-9.4
14	716	689	545	650	-85.8	-19.5
15	783	686	532	667	-125.5	-9.2
16	699	597	384	560	-157.3	-18.5
17	719	653	488	620	-115.6	-16.7
18	737	685	514	645	-111.5	-20.0
19	745	660	526	644	-109.9	-8.3
20	682	602	447	577	-117.9	-12.8
$\bar{x}$	731	658	490	627	-120.5	-15.9
Checks						
21	763	686	513	654	-124.9	-15.9
22	604	572	429	535	-87.5	-18.6
23	727	623	473	608	-127.2	-7.6

[a]Regression coefficients were calculated using more decimal places than given for the mean values presented for this table.

[b]Plant densities.

Table 72. Average silking date for 20 selected inbred lines and three checks in testcross performance, data summarized for three population levels over six environments

Entry no.	Silking date[a] Low[c]	Med	High	Mean	Regression coefficients[b] R_ℓ	R_q
HP group						
01	26.9	27.5	28.8	27.7	0.94	0.13
02	26.7	26.6	27.4	26.9	0.34	0.16
03	28.0	28.4	29.6	28.7	0.80	0.13
04	27.7	28.3	29.4	28.5	0.84	0.10
05	26.9	27.1	28.8	27.6	0.94	0.27
06	28.1	27.9	29.9	28.6	0.87	0.36
07	28.0	28.2	28.7	28.3	0.34	0.05
08	28.2	28.3	29.7	28.7	0.74	0.20
09	25.9	26.1	27.7	26.6	0.90	0.23
10	27.9	27.6	28.5	28.0	0.33	0.20
$\bar{x}$	27.5	27.6	28.9	28.0	0.70	0.18
LP group						
11	28.1	28.3	29.5	28.6	0.67	0.18
12	27.5	27.5	28.9	28.0	0.67	0.24
13	27.3	27.9	29.8	28.3	1.24	0.23
14	28.5	28.3	29.8	28.9	0.64	0.28
15	28.7	29.1	29.7	29.2	0.53	0.04
16	27.7	28.3	30.5	28.8	1.40	0.29
17	28.5	28.7	29.9	29.1	0.70	0.17
18	27.7	28.7	30.2	28.9	1.24	0.08
19	27.4	27.9	29.5	28.2	1.04	0.19
20	27.3	27.6	29.6	28.2	1.17	0.28
$\bar{x}$	27.9	28.2	29.7	28.6	0.93	0.20
Checks						
21	26.7	26.9	27.8	27.1	0.57	0.10
22	29.2	29.9	31.2	30.1	1.00	0.11
23	27.9	28.1	29.5	28.5	0.80	0.18

[a]Coded.

[b]Regression coefficients were calculated using more decimal places than given for the mean values presented for this table.

[c]Plant densities.

Table 73. Average pollen shedding date for 20 selected inbred lines and three checks in testcross performance, data summarized for three population levels over six environments

Entry no.	Shedding date[a] Low[c]	Med	High	Mean	Regression coefficients[b] R_{ℓ}	R_q
HP group						
01	26.4	26.3	26.6	26.4	0.10	0.08
02	27.0	26.5	26.2	26.6	-0.40	0.04
03	27.6	27.7	27.6	27.6	0.00	-0.04
04	27.6	27.2	27.8	27.5	0.10	0.17
05	26.2	25.9	26.3	26.1	0.07	0.13
06	27.8	26.8	27.7	27.4	-0.04	0.32
07	27.1	26.7	26.6	26.8	-0.24	0.06
08	27.5	27.1	27.8	27.4	0.17	0.19
09	25.4	25.3	26.1	25.6	0.37	0.15
10	27.3	27.4	27.7	27.4	0.20	0.02
$\bar{x}$	27.0	26.7	27.1	26.9	0.04	0.11
LP group						
11	27.7	27.3	27.4	27.4	-0.14	0.09
12	26.5	26.0	27.1	26.5	-0.30	0.26
13	26.2	26.7	27.0	26.6	0.40	-0.04
14	28.5	27.7	28.3	28.2	-0.10	0.21
15	28.0	27.5	28.1	27.8	0.04	0.19
16	26.1	26.2	27.5	26.6	0.70	0.19
17	27.5	27.7	27.6	27.6	0.07	-0.05
18	27.6	27.5	27.9	27.6	0.14	0.09
19	26.1	26.4	26.7	26.4	0.27	0.00
20	26.5	26.6	27.4	26.8	0.47	0.11
$\bar{x}$	27.1	27.0	27.5	27.2	0.22	0.11
Checks						
21	26.5	26.7	26.8	26.7	0.14	0.00
22	28.6	27.9	28.4	28.3	-0.10	0.21
23	27.4	27.1	27.5	27.3	0.04	0.10

[a]Coded.

[b]Regression coefficients were calculated using more decimal places than given for the mean values presented for this table.

[c]Plant densities.

Table 74. Average (silking date-shedding date) +10 for 20 selected inbred lines and three checks in testcross performance, data summarized for three population levels over six environments

Entry no.	(Silking date-shedding date) +10 Low[b]	Med	High	Mean	Regression coefficients[a] R_{ℓ}	R_q
HP group						
01	10.5	11.2	12.2	11.3	0.84	0.06
02	9.7	10.1	11.3	10.3	0.77	0.12
03	10.4	10.7	12.0	11.1	0.80	0.18
04	10.1	11.1	11.6	11.0	0.74	-0.09
05	10.7	11.1	12.5	11.5	0.87	0.18
06	10.3	11.1	12.1	11.2	0.90	0.03
07	10.9	11.5	12.1	11.5	0.57	-0.01
08	10.7	11.3	11.9	11.3	0.57	0.01
09	10.5	10.8	11.7	11.0	0.60	0.11
10	10.6	10.2	10.9	10.6	0.14	0.18
$\bar{x}$	10.5	10.9	11.8	11.1	0.68	0.08
LP group						
11	10.5	11.0	12.1	11.2	0.80	0.09
12	11.1	11.5	11.8	11.5	0.37	-0.01
13	11.1	11.1	12.8	11.7	0.84	0.28
14	10.1	10.6	11.5	10.7	0.73	0.07
15	10.7	11.6	11.7	11.4	0.50	-0.14
16	11.7	12.1	13.0	12.2	0.67	0.09
17	11.1	11.1	12.3	11.5	0.63	0.21
18	10.1	11.3	12.3	11.3	1.10	-0.01
19	11.3	11.5	12.8	11.8	0.77	0.19
20	10.8	11.0	12.2	11.4	0.70	0.17
$\bar{x}$	10.8	11.3	12.3	11.5	0.71	0.09
Checks						
21	10.1	10.3	11.0	10.4	0.44	0.10
22	10.6	12.0	12.8	11.8	1.10	-0.10
23	10.5	11.0	12.0	11.2	0.77	0.08

[a]Regression coefficients were calculated using more decimal places than given for the mean values presented for this table.

[b]Plant densities.

Table 75. Average cob length of the two top ears for 20 inbred selections and two check inbreds measured at 3-day intervals during 15 days preceding silk emergence, 1966

Entry no.	Top cob length (cm)						Second cob length (cm)					
	0[a]	3	6	9	12	15	0[a]	3	6	9	12	15
1	12.7	8.0	5.6	4.3	1.9	1.1	6.3	5.0	4.0	2.7	1.2	0.9
2	13.0	8.7	5.9	3.5	2.5	1.6	8.8	6.2	4.5	4.6	1.9	1.1
3	13.8	10.8	6.1	4.4	2.5	1.3	8.8	7.0	3.9	2.9	1.7	1.0
4	14.6	9.1	7.0	4.4	1.8	1.4	10.6	6.6	5.1	3.2	1.4	1.0
5	13.9	8.9	6.0	4.0	1.8	1.7	10.2	5.0	4.8	2.8	1.5	1.2
6	10.6	7.6	9.7	2.9	1.8	1.0	3.7	6.0	4.0	2.1	0.9	0.7
7	14.3	9.5	6.0	3.7	1.9	0.9	11.4	6.1	4.1	3.1	1.5	0.7
8	12.9	9.4	5.4	4.2	2.2	1.8	8.3	6.4	3.7	2.9	1.6	1.3
9	14.9	9.3	5.8	3.7	3.1	1.7	9.1	6.0	3.2	3.3	2.0	1.2
10	13.8	9.5	6.1	5.4	2.1	1.2	9.6	6.5	4.7	3.6	1.7	1.0
11	13.2	10.7	6.5	4.7	2.9	1.7	7.9	4.4	3.9	2.3	1.8	1.3
12	11.1	8.3	6.1	3.6	2.2	1.2	8.0	5.8	4.6	2.9	1.7	1.1
13	12.2	8.0	7.1	4.8	2.5	1.7	7.6	4.6	4.9	3.3	1.7	1.2
14	14.4	8.9	5.0	3.7	2.0	1.4	10.5	6.5	3.8	3.1	1.5	1.2
15	15.0	7.2	7.9	5.6	3.5	1.7	7.4	5.0	5.6	2.9	2.3	1.3
16	14.2	10.0	5.8	4.1	2.7	1.6	7.6	4.9	3.2	2.7	1.8	1.1
17	15.5	10.9	6.1	3.6	2.5	1.4	9.9	7.6	4.7	2.9	1.8	1.1
18	13.8	10.2	5.9	5.1	2.6	1.5	12.1	8.6	5.0	4.0	2.1	1.3
19	18.5	12.8	7.2	3.7	2.4	1.7	9.9	6.8	4.0	2.5	2.0	1.4
20	14.6	10.8	8.2	4.7	1.9	1.9	8.3	7.0	5.4	2.5	1.4	1.3
21	13.4	7.8	6.3	3.4	1.4	1.1	9.3	6.7	5.0	3.1	1.7	1.1
22	14.2	9.6	6.6	3.2	3.2	1.5	2.2	2.4	1.9	0.9	1.2	0.9

[a]Days before 50 percent silking.

Table 76. Average cob length of the two top ears for 20 inbred selections and two check inbreds measured at 3-day intervals during 15 days preceding silk emergence, 1967

	Top cob length (cm)						Second cob length (cm)					
Entry no.	0[a]	3	6	9	12	15	0[a]	3	6	9	12	15
1	11.4	8.4	5.4	3.2	2.5	1.2	5.9	5.7	3.5	2.1	1.8	0.9
2	13.5	8.5	6.3	3.8	2.4	1.3	10.3	7.2	5.2	3.3	1.9	1.1
3	13.9	10.3	7.6	5.2	3.1	1.9	9.9	7.8	6.3	4.2	2.6	1.6
4	13.8	10.0	8.0	3.7	2.3	1.0	9.1	6.9	6.1	3.1	1.7	0.8
5	13.3	9.6	6.8	5.2	2.6	1.3	9.1	6.5	5.2	3.9	2.0	1.0
6	11.7	6.3	6.3	4.5	3.1	1.6	6.5	4.6	3.6	2.9	1.8	1.0
7	15.0	10.3	6.0	6.0	3.2	1.4	11.4	7.6	4.9	4.8	2.6	1.0
8	14.1	9.6	6.7	5.1	3.0	1.8	7.4	6.1	4.4	3.5	1.7	1.1
9	14.5	10.3	7.2	4.2	3.2	2.0	9.2	7.0	5.4	3.2	2.4	1.6
10	14.2	9.6	7.0	5.0	2.9	1.5	11.5	8.2	6.0	4.2	2.4	1.2
11	15.6	10.8	8.6	5.9	3.2	1.0	9.3	7.2	6.4	4.7	2.6	1.5
12	11.8	9.4	7.4	4.4	2.6	1.8	7.9	7.0	6.0	3.5	2.3	1.4
13	13.2	9.7	8.0	5.9	4.4	2.2	9.4	6.4	5.3	4.1	3.0	1.6
14	13.7	9.3	7.4	5.4	3.3	1.7	11.0	7.8	6.2	4.4	3.0	1.2
15	11.7	8.0	5.1	4.6	2.8	2.4	6.8	5.3	4.2	3.3	2.2	2.1
16	15.6	9.4	8.5	5.6	3.5	2.3	7.6	4.5	4.1	3.3	1.8	1.4
17	14.6	10.0	7.4	5.8	3.6	2.8	10.5	7.6	5.5	4.9	2.6	2.0
18	12.3	7.8	5.1	4.2	2.4	1.7	9.6	6.7	3.8	3.6	2.0	1.3
19	16.5	11.2	8.4	4.9	2.7	1.9	12.0	8.5	5.9	3.7	2.0	1.4
20	14.0	10.2	8.4	5.9	3.3	1.5	8.7	7.6	5.6	4.2	2.3	1.1
21	13.3	9.4	6.8	3.8	2.3	1.2	10.0	7.9	6.1	3.6	2.0	1.1
22	12.7	8.9	6.1	4.2	3.1	2.0	3.4	2.0	2.1	2.1	1.2	1.0

[a]Days before 50 percent silking.

Table 77. Analyses of variance of log cob length with time for the two top ears during the 15 days preceding silking for 20 inbred lines and two checks, data obtained in 1966 and 1967

Source of variation	Degrees of freedom			Mean squares			
				1966		1967	
				Top cob[a]	Second cob[a]	Top cob[a]	Second cob[a]
Replications	4			6.1	7.8	6.5	4.9
Entries[b]	21			11.8	56.6**	15.6**	50.5**
Reps x entries {error (a)}	84			10.1	9.7	6.6	7.1
Dates	5			3145.5**	2489.6**	2567.7**	2267.7**
Linear			1	15637.5**	12360.4**	2539.1**	2215.1**
Reminder			4	22.5**	21.9**	7.2**	13.2**
Entries x dates	105			4.5**	6.8**	2.8**	4.5**
Entries x dates linear		21		5.9**	14.4**	6.7**	12.5**
(Selections vs checks) x d_ℓ			1	1.4	68.2**	1.0	13.2*
(Among selections) x d_ℓ			19	6.2**	7.1**	6.3**	9.1**
(HP vs LP) x d_ℓ			1	6.9	16.3*	25.4**	27.9**
(Among HP) x d_ℓ			9	7.2**	7.0*	5.5**	7.0**
(Among LP) x d_ℓ			9	5.2*	6.1	4.9**	9.1**
(Among checks) x d_ℓ			1	5.1	99.6**	20.1**	76.8**
Entries x dates remainder		84		4.1**	4.9*	1.9	2.5
Error (b)	440			2.6	3.6	1.6	2.2
Total	659						

[a]Observed values were multiplied by 10^{-3}.

[b]Orthogonal comparisons based on reasons lines were selected for the study (Table 1).

Table 78. Analyses of variance of lob cob length with time for the two top ears during the 15 days preceding silking for 20 incred lines and two checks, data obtained in 1966 and 1967

Source of variation	Degrees of freedom				Mean squares 1966 Top cob[a]	Mean squares 1966 Second cob[a]	Mean squares 1967 Top cob[a]	Mean squares 1967 Second cob[a]
Replications	4				6.1	7.8	6.5	4.9
Entries[b]	21				11.8	56.6**	15.6**	50.5**
Reps x entries {error (a)}	84				10.1	9.7	6.6	7.1
Dates	5				3145.5**	2489.6**	2567.7**	2267.7**
Linear			1		15637.5**	12360.4**	2539.1**	2215.1**
Reminder			4		22.5**	21.9**	7.2**	13.2**
Entries x dates	105				4.5**	6.8**	2.8**	4.5**
Entries x dates linear		21			5.9**	14.4**	6.7**	12.5**
(Selections vs checks) x d_ℓ			1		1.4	68.2**	1.0	13.2*
(Among selections) x d_ℓ			19		6.2**	7.1**	6.3**	9.1**
0 vs (1&2&3&4) x d_ℓ				1	2.1	2.7	11.9**	9.2*
(1&2) vs (3&4) x d_ℓ				1	1.4	3.8	1.2	6.2
(1 vs 2) x d_ℓ				1	0.0	6.1	6.9*	14.2*
(3 vs 4) x d_ℓ				1	2.6	2.4	1.6	3.5
(Among 0) x d_ℓ				1	5.8	1.0	0.5	3.8
(Among 1) x d_ℓ				4	13.8**	10.7*	16.4**	22.8**
(Among 2) x d_ℓ				3	1.5	6.4	5.0*	1.0
(Among 3) x d_ℓ				4	3.2	3.1	2.1	4.9
(Among 4) x d_ℓ				3	11.4**	14.8**	2.8	7.2*
(Among checks) x d_ℓ			1		5.1	99.6**	20.1**	76.8**
Entries x dates remainder		84			4.1**	4.9*	1.9	2.5
Error (b)	440				2.6	3.6	1.6	2.2
Total	659							

[a] Observed values were multiplied by 10^{-3}.

[b] Orthogonal comparisons based on breeding groups.

Table 79. Cob lengths for the two top ears of the inbred lines at date of silking and linear regression coefficients of log cob length during 15 days preceding silk emergence, data summarized for two years

	1966				1967			
	First cob		Second cob		First cob		Second cob	
Entry no.	Length (cm)	b	Length (cm)	b	Length (cm)	b	Length (cm)	b
1	12.7	0.070	6.3	0.060	11.4	0.064	5.9	0.055
2	13.0	0.061	8.8	0.058	13.5	0.066	10.3	0.064
3	13.8	0.068	8.8	0.064	13.9	0.057	9.9	0.053
4	14.6	0.071	10.6	0.070	13.8	0.076	9.1	0.070
5	13.9	0.065	10.2	0.061	13.3	0.065	9.1	0.061
6	10.6	0.072	3.7	0.032	11.7	0.051	6.5	0.051
7	14.3	0.079	11.4	0.076	15.0	0.063	11.4	0.064
8	12.9	0.060	8.3	0.057	14.1	0.058	7.4	0.056
9	14.9	0.060	9.1	0.055	14.5	0.057	9.2	0.052
10	13.8	0.070	9.6	0.065	14.2	0.063	11.5	0.063
11	13.2	0.060	7.9	0.051	15.6	0.073	9.3	0.052
12	11.1	0.065	8.0	0.058	11.8	0.057	7.9	0.052
13	12.2	0.057	7.6	0.052	13.2	0.048	9.4	0.047
14	14.4	0.068	10.5	0.064	13.7	0.057	11.0	0.059
15	15.0	0.055	7.4	0.048	11.7	0.046	6.8	0.036
16	14.2	0.063	7.6	0.053	15.6	0.054	7.6	0.047
17	15.5	0.070	9.9	0.065	14.6	0.048	10.5	0.047
18	13.8	0.063	12.1	0.065	12.3	0.056	9.6	0.057
19	18.5	0.073	9.9	0.058	16.5	0.065	12.0	0.064
20	14.6	0.066	8.3	0.061	14.0	0.061	8.7	0.059
21	13.4	0.076	9.3	0.063	13.3	0.070	10.0	0.065
22	14.2	0.063	2.2	0.030	12.7	0.053	3.4	0.032

Table 80. Cob lengths of the two top ears for groups of lines at date of silking and regression coefficients of log cob length during 15 days preceding silk emergence, data summarized for two years

	1966				1967			
	First cob		Second cob		First cob		Second cob	
	Length (cm)	b	Length (cm)	b	Length (cm)	b	Length (cm)	b
Selection bases								
High performance group	13.5	0.062	8.7	0.059	13.5	0.068	9.0	0.060
Low performance group	14.3	0.064	8.9	0.058	13.9	0.057	9.3	0.052
Method of breeding								
Testcross at high and low	12.9	0.065	7.6	0.059	12.5	0.065	8.1	0.060
Testcross at high	13.7	0.066	8.5	0.055	12.8	0.061	8.5	0.057
Testcross at low	12.6	0.062	8.1	0.056	13.6	0.060	9.2	0.053
Visual selection high	15.1	0.067	9.8	0.061	14.3	0.060	10.2	0.058
Visual selection low	14.2	0.068	9.3	0.063	14.8	0.054	9.2	0.052
Check M14	13.4	0.076	9.3	0.063	13.3	0.070	10.0	0.065
Check C103	14.2	0.063	2.2	0.030	12.7	0.053	3.4	0.032
Over all selection	13.9	0.066	7.8	0.058	13.5	0.059	8.3	0.055
Testcross selection	13.1	0.064	8.1	0.057	13.0	0.062	8.6	0.057
Visual selection	14.7	0.068	9.6	0.062	14.6	0.057	9.7	0.055

Table 81. Part of the analyses of variance of the top and the second cob final length at silking date, data obtained in 1966 and 1967

Source of variations	Degrees of freedom	Mean squares 1966 Top ear	Mean squares 1966 Second ear	Mean squares 1967 Top ear	Mean squares 1967 Second ear
Entries	21	252.7*	524.1**	186.5**	424.8**
Selections vs checks	1	0.5	1691.4**	94.3	1095.8**
Among selections[a]	19	277.6**	357.6**	200.3**	297.2**
HP vs LP	1	320.0	28.8	64.8	31.3
Among HP	9	153.2	500.6**	133.6	366.5**
Among LP	9	397.4**	251.1**	282.0**	257.5**
Among checks	1	32.0	2520.5**	18.0	2178.0**
Error	84	131.2	70.8	86.8	50.1

[a]Orthogonal comparisons based on reasons lines were selected for the study (Table 1).

Table 82. Part of the analyses of variance of the top and the second cob final length at silking date, data obtained in 1966 and 1967

Source of variations	Degrees of freedom	Mean squares 1966 Top ear	Mean squares 1966 Second ear	Mean squares 1967 Top ear	Mean squares 1967 Second ear
Entries	21	252.7*	524.1**	186.5**	424.8**
Selections vs checks	1	0.5	1691.4**	94.3	1095.8**
Among selections[a]	19	277.6**	357.6**	200.3**	297.2**
0 vs (1&2&3&4)	1	222.2	347.2*	358.4*	247.3*
(1&2) vs (3&4)	1	1042.7**	734.7**	813.4**	440.1**
1 vs 2	1	281.3	36.5	136.9	86.8
3 vs 4	1	178.0	55.6	61.3	211.3*
Among 0	1	4.5	312.5*	220.5	968.0**
Among 1	4	316.0	888.7**	111.8	346.5**
Among 2	3	140.3	26.3	249.6*	73.6
Among 3	4	380.7*	202.0*	224.5*	213.5**
Among 4	3	112.9	288.7**	40.3	410.9**
Among checks	1	32.0	2520.5**	18.0	2178.0**
Error	84	131.2	70.8	86.8	50.1

[a]Orthogonal comparisons based on breeding groups.

Table 83. Average yield in quintals per hectare for testcrosses of four generations in 20 selected families at each location

Family no.	Kanawha 1968	Martinsburg 1968	Newell 1968	Grundy Center 1968	Ames 1968	Ankeny 1968	Newell 1967	Ames 1967
Group 1[a]								
1 Ch	71.8	58.0	72.4	65.6	81.8	81.2	78.1	86.2
F_2	77.1	59.0	71.6	73.2	75.0	70.2	79.6	83.5
F_3	81.3	63.8	72.2	70.1	74.8	73.4	85.1	88.6
F_4	81.9	60.9	73.0	74.4	80.4	73.1	82.9	83.3
2 Ch	74.6	57.0	71.6	67.6	76.3	75.4	69.9	83.1
F_2	76.1	56.4	71.9	75.2	78.2	74.4	71.0	82.4
F_3	76.3	55.9	72.4	80.4	75.7	70.9	81.5	81.8
F_4	80.6	68.6	75.5	79.8	81.5	69.9	72.9	85.8
3 Ch	65.7	57.3	69.1	62.2	78.9	74.0	69.9	81.4
F_2	65.9	55.1	72.4	77.5	75.6	72.9	83.0	85.0
F_3	72.9	61.7	72.4	87.5	79.9	77.2	83.5	90.8
F_4	69.6	56.7	75.8	82.4	76.8	72.0	86.4	94.2
4 Ch	73.6	55.8	73.6	76.9	79.6	74.0	71.4	88.0
F_2	78.7	55.9	73.5	78.2	79.3	69.9	80.1	91.3
F_3	82.4	59.8	75.0	79.6	72.7	67.8	81.7	84.6
F_4	79.1	57.4	73.3	77.6	73.9	71.6	82.4	84.1
5 Ch	74.7	60.2	71.3	69.6	70.2	68.8	72.6	82.2
F_2	81.4	58.1	72.7	69.2	76.6	69.9	75.6	92.5
F_3	77.8	56.2	73.6	66.5	72.6	73.4	77.0	89.4
F_4	75.1	63.2	73.9	80.8	76.9	72.7	80.2	88.2
Mean of								
Group 1 Ch	72.1	57.7	71.6	68.4	77.4	74.7	72.4	84.2
F_2	75.8	56.9	72.4	74.7	76.9	71.5	77.9	86.9
F_3	78.1	59.5	73.1	76.8	75.1	72.5	81.8	87.0
F_4	77.3	61.4	74.3	79.0	77.9	71.9	81.0	87.1

[a]Grouping based on reasons lines were selected for this study (Table 2).

Table 83 (Continued)

Family no.	Kanawha 1968	Martinsburg 1968	Newell 1968	Grundy Center 1968	Ames 1968	Ankeny 1968	Newell 1967	Ames 1967
Group 2[a]								
6 Ch	71.2	63.8	68.4	70.0	81.5	71.7	76.7	80.3
F^2	74.0	44.7	64.6	64.0	72.6	64.9	66.8	85.2
F^3	75.9	54.2	69.1	61.9	69.5	66.7	81.8	80.9
F^4	72.3	52.2	71.5	71.9	72.1	64.2	80.3	77.9
7 Ch	74.0	59.0	71.1	72.8	74.7	73.9	73.1	79.0
F_2	74.2	42.3	60.0	46.0	69.6	63.9	58.0	75.0
F_3	66.7	45.2	67.0	42.5	62.1	62.5	60.9	80.9
F_4	76.6	60.7	67.6	56.9	68.1	65.9	67.8	79.2
8 Ch	79.4	60.5	67.9	68.8	80.4	73.3	73.9	80.6
F_2	73.0	46.7	65.3	63.5	72.1	68.9	72.3	81.7
F_3	64.6	57.6	60.3	64.1	75.8	68.8	69.3	78.8
F_4	70.6	54.0	63.3	56.2	67.1	58.3	65.3	78.9
9 Ch	71.8	60.8	70.3	77.3	74.7	70.0	68.5	83.5
F_2	66.6	49.5	61.3	59.5	70.8	65.2	63.8	76.9
F_3	65.2	52.0	63.7	63.3	72.9	73.3	64.0	78.2
F_4	71.1	48.6	59.4	58.9	67.8	70.1	65.3	74.1
10 Ch	78.6	69.3	76.8	71.6	73.8	73.1	75.7	79.1
F_2	69.4	58.7	64.7	63.3	70.6	67.6	82.2	82.3
F_3	76.7	66.9	72.2	72.9	70.9	65.2	84.0	80.2
F_4	70.4	55.0	68.6	57.2	72.8	68.3	80.8	89.7
Mean of								
Group 2 Ch	75.0	62.7	70.9	72.1	77.0	72.4	73.6	80.5
F_2	71.4	48.4	63.2	57.1	71.1	66.1	68.6	80.2
F_3	69.8	55.2	66.5	60.9	70.2	67.3	72.0	79.8
F_4	72.2	54.1	66.1	60.2	69.6	65.4	71.9	80.0

Table 83 (Continued)

Family no.	Kanawha 1968	Martinsburg 1968	Newell 1968	Grundy Center 1968	Ames 1968	Ankeny 1968	Newell 1967	Ames 1967
Group 3[a]								
11 Ch	78.1	54.2	64.6	72.7	75.2	75.8	64.9	76.4
F_2	72.2	63.8	69.4	64.9	75.8	74.1	77.2	81.1
F_3	76.1	56.4	66.4	73.1	74.3	68.9	73.7	85.2
F_4	79.9	57.7	73.6	64.3	70.4	74.0	76.3	87.2
12 Ch	71.3	56.1	63.4	61.1	78.7	73.7	67.5	88.2
F_2	69.2	58.8	62.1	70.4	73.4	68.3	76.1	83.4
F_3	69.5	60.4	68.6	69.4	69.4	67.0	80.1	90.0
F_4	72.8	63.8	70.2	78.9	74.7	68.8	84.4	88.8
13 Ch	73.6	56.5	69.1	66.7	81.8	73.4	79.5	84.5
F_2	79.5	58.0	75.5	72.6	72.9	70.5	73.4	80.6
F_3	83.2	62.3	74.1	75.2	82.4	71.9	82.7	80.4
F_4	85.3	63.1	71.7	76.7	78.2	70.8	80.9	77.8
14 Ch	67.2	52.0	74.8	76.4	72.5	72.8	76.6	75.4
F_2	67.3	54.1	73.0	75.4	78.6	72.8	76.9	85.0
F_3	77.5	60.8	75.9	78.6	76.9	68.7	80.8	78.6
F_4	79.2	61.6	73.7	73.4	76.5	73.6	80.1	83.5
15 Ch	77.7	58.1	66.3	66.8	78.6	68.4	70.6	83.7
F_2	81.2	61.1	75.5	71.7	77.9	79.6	81.4	81.3
F_3	77.9	62.7	77.5	80.9	70.9	73.5	79.8	83.6
F_4	79.5	62.1	68.9	86.1	78.1	75.0	80.4	91.2
Mean of								
Group 3 Ch	73.6	55.4	67.6	68.4	77.4	72.8	71.8	81.6
F_2	73.9	59.2	71.1	71.0	75.7	73.1	77.0	82.3
F_3	76.8	60.5	72.5	75.4	74.8	70.0	79.4	83.6
F_4	79.3	61.7	71.6	75.9	75.6	72.4	80.4	85.7

Table 83 (Continued)

Family no.	Kanawha 1968	Martinsburg 1968	Newell 1968	Grundy Center 1968	Ames 1968	Ankeny 1968	Newell 1967	Ames 1967
Group 4[a]								
16 Ch	70.2	54.6	69.0	66.2	76.0	71.6	78.0	79.5
F_2	74.9	56.8	72.1	75.2	74.6	76.1	73.8	74.9
F_3	77.6	56.7	71.6	79.2	80.4	70.3	75.4	75.2
F_4	73.9	57.3	77.0	70.8	74.6	71.4	74.7	83.6
17 Ch	65.7	54.6	64.6	66.0	76.0	70.8	69.5	72.5
F_2	77.1	56.0	75.0	70.1	75.7	70.9	66.7	79.2
F_3	74.6	60.4	71.6	65.7	79.4	76.8	67.6	80.5
F_4	70.5	58.7	68.2	70.5	76.7	67.8	63.6	78.2
18 Ch	74.8	51.2	65.9	68.6	80.1	69.2	75.1	76.4
F_2	76.2	43.5	67.6	68.7	75.7	69.8	77.5	76.8
F_3	75.2	55.2	67.9	73.2	76.6	77.3	69.6	85.9
F_4	81.7	53.8	77.0	77.6	77.8	74.9	73.5	80.1
19 Ch	78.1	54.7	65.7	69.1	81.4	74.9	66.6	79.5
F_2	76.7	61.6	71.0	76.0	79.8	72.1	78.4	82.3
F_3	76.8	53.4	63.7	65.6	75.8	66.9	74.3	79.0
F_4	73.1	55.0	67.0	61.6	69.7	71.6	75.6	75.3
20 Ch	73.0	56.9	71.7	68.8	79.1	73.5	72.8	83.4
F_2	71.4	57.2	66.6	66.6	72.0	67.7	70.5	89.2
F_3	74.0	58.3	65.7	65.8	78.8	72.0	70.2	82.7
F_4	74.5	59.2	70.1	73.4	78.2	68.4	68.5	81.8
Mean of								
Group 4 Ch	72.4	54.4	67.4	67.7	78.5	72.0	72.4	78.3
F_2	75.3	55.0	70.5	71.3	75.6	71.3	73.4	80.5
F_3	75.6	56.8	68.1	69.9	78.2	72.7	71.4	80.7
F_4	74.7	56.8	71.9	70.8	75.4	70.8	71.2	79.8

Table 84. Analyses of variance of yield in eight environments for test-crosses of four generations in 20 selected families

Source of variations	Degrees of freedom		Mean squares Kanawha 1968	Martinsburg 1968	Newell 1968	Grundy Center 1968
Replications	2		314.86**	19.48	4.99	35.33
Families[a]	19		45.58	39.42*	41.49**	130.25**
(1&2) vs (3&4)		1	30.38	5.00	2.08	141.25*
1 vs 2		1	138.01*	141.75*	384.40**	1472.58**
3 vs 4		1	19.88	117.31*	16.00	75.08
Among 1		4	68.21	7.17	1.48	44.88
Among 2		4	16.74	72.97*	33.36**	85.61*
Among 3		4	67.44	9.86	44.98**	44.52
Among 4		4	17.06	31.25	16.65*	21.44
Error (a)	38		28.63	20.95	6.36	25.90
Generations	3		26.43*	52.20**	12.05	38.01
Linear		1	79.12**	35.76**	30.53*	85.10*
Quadratic		1	0.03	49.61**	5.15	8.91
Cubic		1	0.15	71.23**	0.46	20.03
Families x generations	57		13.86**	20.48**	12.25**	45.82**
{(1&2)vs(3&4)}x gen	3		9.26	84.50**	41.81**	54.66*
Linear		1	24.85	74.13**	44.69**	65.53
Quadratic		1	2.63	114.24**	40.47**	71.25*
Cubic		1	0.31	65.13**	40.26*	27.20
(1 vs 2) x generations	3		56.26**	93.57**	36.42**	282.86**
Linear		1	97.02**	133.01**	49.60**	540.88**
Quadratic		1	69.96**	69.96**	30.63*	212.06**
Cubic		1	1.79	77.75**	29.03*	95.63*
(3 vs 4) x generations	3		15.03	7.20	11.25	22.65
Linear		1	20.23	15.74	0.64	46.27
Quadratic		1	22.50	2.55	15.75	0.17
Cubic		1	2.38	3.30	17.35	21.52
Among 1 x generations	12		6.79	11.08	1.62	26.56
Linear		4	8.67	7.15	3.09	30.68
Quadratic		4	5.84	15.88	0.85	39.83
Cubic		4	10.20	5.87	0.92	9.18
Among 2 x generations	12		22.35**	17.02**	9.66	49.99**
Linear		4	16.89	13.10	14.33	36.82
Quadratic		4	38.97**	15.25	2.03	102.64**
Cubic		4	11.19	22.71*	12.63	10.50

[a]Orthogonal comparisons based on reasons lines were selected for the study (Table 2).

Table 84 (Continued)

Source of variations	Degrees of freedom		Mean squares			
			Kanawha 1968	Martinsburg 1968	Newell 1968	Grundy Center 1968
Among 3 x generations	12		6.87	11.82	11.49*	27.82
Linear		4	7.57	21.32*	6.84	62.14
Quadratic		4	3.10	7.48	19.65*	2.00
Cubic		4	9.94	6.66	7.99	19.28
Among 4 x generations	12		10.65	10.04	13.06*	23.25
Linear		4	5.47	8.87	14.58*	29.46
Quadratic		4	4.90	17.15	21.40*	31.26
Cubic		4	21.57*	4.11	3.20	9.16
Error (b)	120		7.97	7.21[b]	5.90	16.78
Total	239					
c.v. %			6.21	5.96	6.02	10.14
			Ames 1968	Ankeny 1968	Newell 1967	Ames 1967
Replications	2		31.49*	127.61**	41.03	407.68**
Families[a]	19		26.90**	22.40*	100.59**	49.29
(1&2) vs (3&4)		1	78.01**	56.28*	1.28	55.45
1 vs 2		1	234.26**	234.74**	450.91**	384.40**
3 vs 4		1	11.24	1.44	257.05*	123.20
Among 1		4	11.31	10.65	39.70	16.00
Among 2		4	18.97	6.63	189.49**	14.57
Among 3		4	16.15	12.55	23.84	35.06
Among 4		4	0.74	3.44	47.48	27.72
Error (a)	38		7.26	10.66	41.80	33.65
Generations	3		41.82**	33.80**	59.81**	15.28
Linear		1	82.81**	70.98**	159.90**	40.07
Quadratic		1	37.81*	19.70	14.54	4.42
Cubic		1	4.84	10.73	5.00	1.35
Families x generations	57		11.31	11.21*	19.47**	13.62
{(1&2)vs(3&4)}x gen	3		8.37	21.26*	11.39	2.93
Linear		1	6.76	27.30*	1.81	8.35
Quadratic		1	10.51	10.73	4.95	0.16
Cubic		1	7.84	25.76	27.41	0.27

[b] Error degrees of freedom is only 119 due to the use of the analysis of covariance on the yield only.

Table 84 (Continued)

Source of variations	Degrees of freedom	Mean squares Ames 1968	Ankeny 1968	Newell 1967	Ames 1967
(1 vs 2) x generations	3	27.74*	8.12	69.83**	7.19
Linear	1	66.36**	19.66	122.46**	15.02
Quadratic	1	2.60	2.07	77.56**	6.08
Cubic	1	14.26	2.62	9.46	0.46
(3 vs 4) x generations	3	7.24	10.69	50.00**	7.76
Linear	1	0.02	0.50	143.14**	9.77
Quadratic	1	3.25	7.06	5.48	13.46
Cubic	1	18.24	24.50	1.38	0.06
Among 1 x generations	12	10.00	8.97	9.31	15.49
Linear	4	12.70	11.17	8.33	27.32*
Quadratic	4	7.82	10.29	4.92	8.73
Cubic	4	9.49	5.44	14.69	10.43
Among 2 x generations	12	9.15	12.43	25.49**	13.82
Linear	4	8.66	18.46*	25.39*	22.79
Quadratic	4	9.18	13.55	35.77**	7.10
Cubic	4	11.42	5.28	15.33	11.57
Among 3 x generations	12	13.47	8.87	13.90	15.38
Linear	4	6.15	6.40	13.94	23.58
Quadratic	4	14.35	12.20	9.30	8.15
Cubic	4	19.90*	8.03	18.47	14.41
Among 4 x generations	12	9.66	12.98*	10.97	15.54
Linear	4	17.40	12.26	13.16	14.63
Quadratic	4	7.43	9.86	7.44	20.51
Cubic	4	4.14	16.83*	12.31	11.48
Error (b)	120	7.55[b]	6.90	8.98	10.38[b]
Total	239				
c.v. %		5.91	6.40	6.71	6.77

Table 85. Average moisture content at harvest for testcrosses of four generations in 20 selected families at each location

Family no.	Kanawha 1968	Martinsburg 1968	Newell 1968	Grundy Center 1968	Ames 1968	Ankeny 1968	Newell 1967	Ames 1967
Group 1[a]								
1 Ch	27.9	21.2	23.1	24.8	22.4	20.0	28.2	24.4
F_2	28.9	20.4	26.7	24.9	23.4	22.0	29.8	25.0
F_3	27.3	19.4	24.5	23.6	22.3	20.9	26.0	23.3
F_4	26.6	18.7	24.9	23.0	23.1	20.7	25.7	22.4
2 Ch	28.7	20.8	26.3	24.8	23.9	20.4	26.6	23.6
F_2	29.0	21.0	26.4	26.4	23.8	22.5	30.3	24.8
F_3	30.0	23.1	28.6	27.9	26.7	24.0	30.9	25.1
F_4	30.9	22.8	28.1	27.0	24.4	24.1	32.1	25.2
3 Ch	28.5	21.4	26.1	25.6	22.8	20.8	20.3	22.4
F_2	28.2	21.6	25.6	24.2	23.3	21.3	29.2	23.9
F_3	27.4	20.0	25.5	24.3	23.2	20.5	28.7	23.4
F_4	27.5	20.1	26.7	24.7	23.3	19.7	27.0	23.8
4 Ch	28.2	20.7	25.6	24.6	22.9	21.1	28.4	23.1
F_2	30.3	20.9	26.5	25.5	24.2	22.5	27.9	24.2
F_3	29.4	21.4	27.4	25.4	24.0	21.4	31.4	22.6
F_4	31.0	23.6	28.8	26.8	24.0	23.3	29.3	24.9
5 Ch	27.1	20.6	24.5	24.7	22.9	20.1	29.1	22.4
F_2	27.2	21.7	25.5	25.1	23.2	21.5	29.9	23.2
F_3	26.5	20.1	26.3	24.9	23.8	20.2	27.7	22.7
F_4	26.9	20.7	26.3	24.0	22.1	20.6	26.9	22.5
Mean of								
Group 1 Ch	28.1	20.9	25.1	24.9	23.0	20.5	28.5	23.2
F_2	28.8	21.1	26.1	25.2	23.6	22.0	29.4	24.2
F_3	28.1	20.8	26.5	25.2	24.0	21.4	28.9	23.4
F_4	28.6	21.2	27.0	25.1	23.4	21.7	28.2	23.8

[a]Grouping based on reasons lines were selected for this study (Table 2).

Table 85 (Continued)

Family no.	Kanawha 1968	Martinsburg 1968	Newell 1968	Grundy Center 1968	Ames 1968	Ankeny 1968	Newell 1967	Ames 1967
Group 2[a]								
6 Ch	29.3	20.2	25.5	25.8	23.2	19.7	29.1	24.7
F_2	25.5	19.9	26.9	22.4	22.0	18.5	26.4	21.8
F_3	25.8	18.2	25.1	23.9	21.0	17.6	25.3	22.4
F_4	24.8	18.0	23.9	22.9	21.5	18.4	26.0	21.2
7 Ch	27.4	20.6	27.2	25.1	23.2	21.0	28.1	24.1
F_2	26.3	19.2	25.5	24.4	22.0	19.3	28.5	21.9
F_3	27.9	20.9	26.5	25.0	22.9	19.6	27.2	22.8
F_4	26.6	19.6	26.6	24.4	23.2	19.2	26.8	23.3
8 Ch	26.6	20.8	24.9	24.4	21.7	21.6	28.0	23.4
F_2	29.9	21.6	25.4	24.7	22.5	21.9	28.6	23.0
F_3	30.1	20.0	24.8	24.0	21.4	21.4	30.0	24.5
F_4	28.7	18.0	25.6	23.4	22.6	18.8	28.5	23.3
9 Ch	29.5	21.8	25.8	24.4	22.2	22.0	29.6	24.3
F_2	29.9	22.7	30.3	26.4	25.5	23.2	31.7	27.0
F_3	31.2	23.4	29.4	26.5	24.7	23.8	31.3	27.5
F_4	29.6	23.2	29.5	27.8	26.0	23.6	31.5	26.2
10 Ch	27.7	20.4	25.7	23.9	22.9	21.1	27.9	23.4
F_2	25.7	19.3	24.7	22.5	20.4	19.6	24.1	21.5
F_3	26.0	20.3	24.0	24.6	23.1	20.6	25.8	22.2
F_4	26.0	19.8	24.7	23.2	21.2	18.9	24.0	21.1
Mean of								
Group 2 Ch	28.1	20.8	25.8	24.7	22.6	21.1	28.5	24.0
F_2	27.5	20.5	26.6	24.1	22.9	20.5	27.9	23.0
F_3	28.2	20.6	26.0	24.8	22.6	20.6	27.9	23.9
F_4	27.1	19.7	26.1	24.3	22.9	19.8	27.4	23.0

Table 85 (Continued)

Family no.	Kanawha 1968	Martinsburg 1968	Newell 1968	Grundy Center 1968	Ames 1968	Ankeny 1968	Newell 1967	Ames 1967
Group 3[a]								
11 Ch	28.5	20.4	26.1	25.1	22.9	21.0	30.3	24.1
F_2	28.2	20.5	25.7	25.0	22.6	22.1	28.6	23.6
F_3	26.4	18.7	25.0	22.5	22.5	20.2	27.3	22.4
F_4	26.4	19.5	25.9	22.7	21.9	21.2	29.3	22.8
12 Ch	28.9	21.0	25.9	24.1	22.7	20.5	29.8	22.6
F_2	27.4	19.9	27.0	23.5	21.9	19.1	26.6	21.5
F_3	26.4	19.0	26.0	23.7	22.5	19.4	25.7	20.8
F_4	26.2	18.9	25.5	23.9	22.2	18.4	26.0	21.8
13 Ch	27.7	20.9	25.9	24.0	22.8	20.3	27.7	23.7
F_2	27.6	20.6	25.4	24.4	22.9	19.5	28.9	23.5
F_3	28.5	19.8	26.6	25.8	23.0	22.0	29.4	23.2
F_4	27.5	19.5	26.8	26.0	23.4	21.2	29.6	23.9
14 Ch	28.9	20.2	24.5	24.2	22.4	20.3	27.0	25.0
F_2	29.1	19.4	25.2	24.0	23.3	20.6	27.4	22.9
F_3	25.8	19.5	25.5	25.7	23.5	21.2	27.0	23.2
F_4	27.7	19.7	24.7	23.9	22.7	20.0	27.0	23.9
15 Ch	28.1	20.9	26.8	26.5	25.1	21.8	29.4	23.7
F_2	31.4	23.2	28.7	27.8	26.7	25.4	32.3	27.2
F_3	31.5	24.5	28.8	26.5	25.5	24.2	34.0	27.0
F_4	33.5	25.6	31.5	27.0	26.7	25.4	33.8	27.8
Mean of								
Group 3 Ch	28.4	20.7	25.8	24.8	23.2	20.8	28.8	23.8
F_2	28.7	20.7	26.4	24.9	23.5	21.3	28.8	23.7
F_3	27.7	20.3	26.4	24.8	23.4	21.4	28.7	23.3
F_4	28.3	20.6	26.9	24.7	23.4	21.2	29.1	24.0

Table 85 (Continued)

Family no.	Kanawha 1968	Martinsburg 1968	Newell 1968	Grundy Center 1968	Ames 1968	Ankeny 1968	Newell 1967	Ames 1967
Group 4[a]								
16 Ch	28.4	20.7	26.1	25.0	22.1	20.8	29.5	22.8
F_2	28.1	20.6	26.7	25.4	23.2	22.1	30.7	24.8
F_3	29.0	20.6	27.9	26.9	22.7	21.8	30.7	24.8
F_4	29.1	20.8	26.0	25.8	22.5	20.6	29.1	23.1
17 Ch	30.2	20.6	26.6	23.7	23.6	21.6	29.3	23.7
F_2	27.7	20.0	24.9	23.8	21.6	20.9	26.2	22.8
F_3	27.3	21.0	25.1	24.6	22.2	21.8	27.9	23.2
F_4	26.7	20.9	26.3	23.4	22.9	22.3	25.3	23.1
18 Ch	27.7	20.4	26.7	24.2	22.4	21.4	27.8	24.1
F_2	26.6	21.1	26.1	25.3	22.3	21.2	26.9	25.8
F_3	27.1	22.2	25.7	24.5	22.1	22.0	27.3	23.3
F_4	26.6	21.3	25.2	23.3	22.5	20.7	25.3	23.0
19 Ch	28.2	20.2	28.1	25.1	22.2	20.3	27.9	24.7
F_2	29.3	21.9	26.0	25.3	22.3	22.1	29.7	24.9
F_3	28.9	20.2	27.0	24.5	21.6	20.0	27.2	23.6
F_4	30.4	22.1	26.6	25.9	23.2	20.5	29.2	24.2
20 Ch	27.9	21.1	25.4	24.7	23.5	21.5	30.3	24.4
F_2	27.9	21.5	25.8	23.7	23.0	19.4	27.3	21.6
F_3	30.6	21.9	26.1	24.8	23.2	20.7	29.0	23.7
F_4	27.2	21.7	25.8	25.1	23.5	20.5	30.5	23.4
Mean of								
Group 4 Ch	28.5	20.6	26.6	24.5	22.8	21.1	29.0	23.9
F_2	27.9	21.0	25.9	24.7	22.5	21.1	28.2	24.0
F_3	28.6	21.2	26.4	25.1	22.4	21.3	28.4	23.7
F_4	28.4	21.4	26.0	24.7	22.9	20.9	27.9	23.4

Table 86. Analyses of variance of grain moisture in eight environments for testcrosses of four generations in 20 selected families

Source of variations	Degrees of freedom		Mean squares			
			Kanawha 1968	Martinsburg 1968	Newell 1968	Grundy Center 1968
Replications	2		1.90	0.45	2.17**	1.68*
Families[a]	19		6.74**	4.97**	5.34**	3.88**
(1&2) vs (3&4)		1	1.41	0.24	0.48	0.00
1 vs 2		1	4.23	3.78**	0.05	3.91**
3 vs 4		1	0.05	2.07*	0.29	0.04
Among 1		4	6.27**	2.53**	4.40**	3.65**
Among 2		4	10.85**	7.79**	10.32**	4.81**
Among 3		4	10.40**	11.16**	9.20**	6.76**
Among 4		4	3.08*	0.61	1.23*	2.23**
Error (a)	38		1.08	0.38	0.35	0.46
Generations	3		0.11	0.08	1.42	0.32
Linear		1	0.34	0.04	3.73*	0.03
Quadratic		1	0.00	0.04	0.26	0.36
Cubic		1	0.00	0.16	0.26	0.58
Families x generations	57		1.47**	0.99**	1.03**	0.83**
{(1&2)vs(3&4)}x gen	3		0.21	0.51	0.87	0.09
Linear		1	0.00	1.32*	1.10	0.01
Quadratic		1	0.45	0.07	0.61	0.10
Cubic		1	0.10	0.12	0.90	0.17
(1 vs 2) x generations	3		1.65*	0.87*	1.42	0.44
Linear		1	1.16	1.53*	4.09**	0.13
Quadratic		1	0.04	0.42	0.01	0.24
Cubic		1	3.75**	0.66	0.17	0.94
(3 vs 4) x generations	3		1.18	0.47	1.24	0.12
Linear		1	0.46	1.11*	2.46*	0.17
Quadratic		1	0.02	0.18	0.08	0.03
Cubic		1	3.08**	0.11	1.19	0.16
Among 1 x generations	12		0.82*	1.35**	0.86	0.98*
Linear		4	1.95**	3.17**	0.61	2.04**
Quadratic		4	0.22	0.27	0.84	0.68
Cubic		4	0.28	0.62	1.14	0.22
Among 2 x generations	12		1.83**	1.01**	1.54**	1.23**
Linear		4	2.75**	1.84**	2.05**	2.16**
Quadratic		4	2.32**	0.47	1.89*	0.43
Cubic		4	0.42	0.71*	0.69	1.11*

[a]Orthogonal comparisons based on reasons lines were selected for the study (Table 2).

Table 86 (Continued)

Source of variations	Degrees of freedom		Mean squares			
			Kanawha 1968	Martinsburg 1968	Newell 1968	Grundy Center 1968
Among 3 x generations	12		2.35**	1.53**	1.02*	1.03**
Linear		4	5.63**	4.18**	2.20**	1.86**
Quadratic		4	0.43	0.22	0.48	0.22
Cubic		4	0.99	0.19	0.42	1.00
Among 4 x generations	12		1.24**	0.36	0.56	0.52
Linear		4	2.71**	0.12	0.39	0.40
Quadratic		4	0.35	0.19	1.10	0.69
Cubic		4	0.66	0.78*	0.19	0.47
Error (b)	120		0.45	0.26	0.59	0.43
Total	239					
c.v. %			4.14	4.25	5.09	4.57
			Ames 1968	Ankeny 1968	Newell 1967	Ames 1967
Replications	2		0.39	3.88**	5.52*	3.84*
Families[a]	19		4.36**	6.69**	10.64**	5.45**
(1&2) vs (3&4)		1	0.06	0.92	1.35	0.63
1 vs 2		1	6.01**	7.92**	7.23*	0.27
3 vs 4		1	5.33**	0.06	2.50	0.00
Among 1		4	2.59**	3.85**	3.63	2.05
Among 2		4	5.28**	11.73**	18.03**	10.84**
Among 3		4	9.08**	13.09**	18.82**	11.77**
Among 4		4	0.64	0.87	7.31**	0.99
Error (a)	38		0.52	0.33	1.60	0.86
Generations	3		0.19	0.68	1.15	0.20
Linear		1	0.50	0.00	3.13	0.51
Quadratic		1	0.07	1.99*	0.16	0.02
Cubic		1	0.00	0.06	0.15	0.09
Families x generations	57		0.69	0.97**	2.19**	1.06**
{(1&2)vs(3&4)}x gen		3	0.36	0.13	0.74	0.22
Linear		1	0.07	0.18	0.48	0.03
Quadratic		1	0.70	0.04	1.68	0.33
Cubic		1	0.30	0.15	0.07	0.30
(1 vs 2) x generations		3	0.75	2.98**	1.08	2.24**
Linear		1	0.00	5.85**	0.52	1.11
Quadratic		1	2.16*	0.58	1.94	0.38
Cubic		1	0.10	2.51*	0.77	5.22**

Table 86 (Continued)

Source of variations	Degrees of freedom	Mean squares			
		Ames 1968	Ankeny 1968	Newell 1967	Ames 1967
(3 vs 4) x generations	3	0.28	0.21	0.86	0.58
Linear	1	0.00	0.46	1.81	0.63
Quadratic	1	0.84	0.08	0.05	0.90
Cubic	1	0.00	0.09	0.72	0.20
Among 1 x generations	12	0.54	0.88*	3.52**	0.64
Linear	4	0.38	2.01**	7.92**	1.36**
Quadratic	4	0.15	0.29	0.12	0.29
Cubic	4	1.09	0.33	2.52*	0.25
Among 2 x generations	12	1.50**	0.92*	1.81*	1.31**
Linear	4	1.93**	1.46**	2.64*	1.97**
Quadratic	4	0.54	0.99	1.51	1.71**
Cubic	4	2.01**	0.32	1.27	0.26
Among 3 x generations	12	0.31	1.32**	2.56**	1.27**
Linear	4	0.34	1.83**	5.34**	2.39**
Quadratic	4	0.19	0.35	2.20*	1.12*
Cubic	4	0.40	1.79**	0.13	0.29
Among 4 x generations	12	0.29	0.68	1.87*	1.06**
Linear	4	0.09	0.19	1.51	0.31
Quadratic	4	0.54	0.85	1.83	1.50**
Cubic	4	0.24	0.99	2.26*	1.36**
Error (b)	120	0.53	0.42	0.83	0.38
Total	239				
c.v. %		4.68	5.33	5.55	4.51

Table 87. Analyses of variance of yield in eight environments for test-crosses of four generations in 20 selected families

Source of variations	Degrees of freedom		Mean squares			
			Kanawha 1968	Martinsburg 1968	Newell 1968	Grundy Center 1968
Replications	2		314.86**	19.48	4.99	35.33
Families[a]	19		45.58	39.42*	41.49**	130.25**
(1&2) vs (3&4)		1	30.38	5.00	2.08	141.35*
1 vs 2		1	7.42	133.65*	190.28**	580.33**
3 vs 4		1	0.35	9.05	3.48	19.04
Among 1		3	79.19	22.57	7.54	123.28**
Among 2		5	46.56	52.19*	62.17**	208.87**
Among 3		3	34.09	17.46	45.91**	77.24*
Among 4		5	51.04	44.06	24.26**	17.63
Error (a)	38		28.63	20.95	6.36	25.90
Generations	3		26.43*	52.20**	12.05	38.01
Linear		1	79.12**	35.76**	30.53*	85.10*
Quadratic		1	0.03	49.61**	5.15	8.91
Cubic		1	0.15	71.23**	0.46	20.03
Families x generations	57		13.86**	20.48**	12.25**	45.82**
{(1&2)vs(3&4)}x gen	3		9.26	84.50**	41.81**	54.66*
Linear		1	24.85	74.13**	44.69**	65.53
Quadratic		1	2.63	114.24**	40.47**	71.25*
Cubic		1	0.31	65.13**	40.26*	27.20
(1 vs 2) x generations	3		27.81*	29.93**	5.16	78.20**
Linear		1	0.26	0.27	5.98	93.19*
Quadratic		1	45.94*	88.94**	9.48	141.37**
Cubic		1	37.24*	0.59	0.01	0.05
(3 vs 4) x generations	3		3.33	2.22	17.69*	4.33
Linear		1	4.70	1.53	49.09**	10.53
Quadratic		1	0.76	0.99	1.19	0.91
Cubic		1	4.53	4.13	2.79	1.56
Among 1 x generations	9		14.27	16.53*	10.40	61.00**
Linear		3	16.18	21.73*	12.24	96.76**
Quadratic		3	7.91	8.09	5.61	52.56*
Cubic		3	15.88	19.77*	13.36	33.35
Among 2 x generations	15		16.85*	29.56**	9.04	65.64**
Linear		5	27.06*	32.75**	15.32*	85.49**
Quadratic		5	16.93	35.24**	3.17	96.58**
Cubic		5	6.55	20.69*	8.62	14.85

[a]Orthogonal comparisons based on breeding groups.

Table 87 (Continued)

Source of variations	Degrees of freedom		Mean squares			
			Kanawha 1968	Martinsburg 1968	Newell 1968	Grundy Center 1968
Among 3 x generations	9		14.14	9.64	14.83*	38.70*
Linear		3	33.32*	15.71	2.34	86.77**
Quadratic		3	1.32	1.67	31.89**	19.95
Cubic		3	7.75	11.54	10.27	12.71
Among 4 x generations	15		11.34	9.23	9.45	20.64
Linear		5	7.25	3.84	6.04	28.27
Quadratic		5	23.26*	5.71	16.62*	14.33
Cubic		5	3.54	18.12*	5.70	19.16
Error (b)	120		7.97	7.21[b]	5.90	16.78
Total	239					
c.v. %			6.21	5.96	6.02	10.14
			Ames 1968	Ankeny 1968	Newell 1967	Ames 1967
Replications	2		31.49*	127.61**	41.03	407.68**
Families[a]	19		26.90**	22.40*	100.59**	49.29
(1&2) vs (3&4)		1	78.01**	56.28*	1.28	55.45
1 vs 2		1	11.40	23.44	487.07**	276.06**
3 vs 4		1	0.68	0.17	9.24	53.76
Among 1		3	25.56*	20.18	16.84	24.06
Among 2		5	53.06**	43.98**	166.41**	31.69
Among 3		3	0.60	9.95	58.59	32.57
Among 4		5	15.26	7.08	71.47	52.97
Error (a)	38		7.26	10.66	41.80	33.65
Generations	3		41.82**	33.80**	59.81**	15.28
Linear		1	82.81**	70.98**	159.90**	40.07
Quadratic		1	37.81*	19.70	14.54	4.42
Cubic		1	4.84	10.73	5.00	1.35
Families x generations	57		11.31	11.21*	19.47**	13.62
{(1&2)vs(3&4)}x gen	3		8.37	21.26*	11.39	2.93
Linear		1	6.76	27.30*	1.81	8.35
Quadratic		1	10.51	10.73	4.95	0.16
Cubic		1	7.84	25.76	27.41	0.27

[b]Error degrees of freedom is only 119 due to the use of the analysis of covariance on the yield only.

Table 87 (Continued)

Source of variations	Degrees of freedom	Mean squares			
		Ames 1968	Ankeny 1968	Newell 1967	Ames 1967
(1 vs 2) x generations	3	14.62	14.91	75.82**	32.60*
Linear	1	24.80	36.75*	101.91**	66.84*
Quadratic	1	15.25	1.07	64.38**	2.32
Cubic	1	3.80	6.90	61.16*	28.64
(3 vs 4) x generations	3	6.15	4.70	5.05	20.63
Linear	1	1.08	0.04	0.94	9.52
Quadratic	1	0.34	0.83	11.05	2.46
Cubic	1	17.04	13.13	3.15	49.90*
Among 1 x generations	9	9.14	7.96	6.07	17.25
Linear	3	13.24	9.38	10.21	35.95*
Quadratic	3	2.27	10.69	5.86	13.77
Cubic	3	11.90	3.81	2.12	5.39
Among 2 x generations	15	12.90	10.98	23.01**	7.34
Linear	5	17.45*	14.65	24.96*	8.15
Quadratic	5	9.71	12.86	31.67**	5.16
Cubic	5	11.68	5.43	12.40	8.72
Among 3 x generations	9	17.82*	13.12	11.81	14.77
Linear	3	8.14	8.16	16.76	6.98
Quadratic	3	13.36	14.43	8.69	16.14
Cubic	3	15.64	16.77	9.97	7.26
Among 4 x generations	15	8.00	10.82	21.80**	13.30
Linear	5	4.14	10.12	40.07**	18.06
Quadratic	5	9.80	10.23	7.06	15.44
Cubic	5	10.09	12.10	18.28	6.39
Error (b)	120	7.55[b]	6.90	8.98	10.38[b]
Total	239				
c.v. %		5.91	6.40	6.71	6.77

Table 88. Analyses of variance of grain moisture in eight environments for testcrosses of four gnerations in 20 selected families

Source of variations	Degrees of freedom		Mean squares Kanawha 1968	Martinsburg 1968	Newell 1968	Grundy Center 1968
Replications	2		1.90	0.45	2.17**	1.68*
Families[a]	19		6.74**	4.97**	5.34**	3.88**
(1&2) vs (3&4)		1	1.41	0.24	0.48	0.00
1 vs 2		1	2.82	0.19	1.89*	0.79
3 vs 4		1	24.58**	11.70**	3.58**	6.97**
Among 1		3	8.75**	1.93**	3.61**	2.76**
Among 2		5	8.73**	7.82**	9.24**	5.73**
Among 3		3	7.37**	10.14**	11.92**	5.31**
Among 4		5	1.43	1.41**	0.54	2.62**
Error (a)	38		1.08	0.38	0.35	0.46
Generations	3		0.11	0.08	1.42	0.32
Linear		1	0.34	0.04	3.72*	0.03
Quadratic		1	0.00	0.04	0.26	0.36
Cubic		1	0.00	0.16	0.26	0.58
Families x generations	57		1.47**	0.99**	1.03**	0.83**
{(1&2)vs(3&4)}x gen	3		0.21	0.51	0.87	0.09
Linear		1	0.00	1.32*	1.10	0.01
Quadratic		1	0.45	0.07	0.61	0.10
Cubic		1	0.18	0.12	0.90	0.17
(1 vs 2) x generations	3		0.84	0.87*	1.11	0.10
Linear		1	0.00	1.02*	0.16	0.03
Quadratic		1	1.20	0.84	2.84*	0.24
Cubic		1	1.32	0.75	0.32	0.03
(3 vs 4) x generations	3		4.76**	1.96**	0.64	0.22
Linear		1	12.36**	5.60**	1.91	0.32
Quadratic		1	0.34	0.05	0.00	0.32
Cubic		1	1.58	0.24	0.00	0.01
Among 1 x generations	9		0.80	0.98**	0.76	0.70
Linear		3	1.57*	1.94**	1.85*	0.89
Quadratic		3	0.24	0.30	0.41	0.41
Cubic		3	0.55	0.69	0.03	0.80
Among 2 x generations	15		1.80**	1.30**	1.53**	1.41**
Linear		5	3.05**	2.94**	1.81*	2.84**
Quadratic		5	1.64**	0.33	1.37*	0.65
Cubic		5	0.71	0.63*	1.41*	0.76

[a]Orthogonal comparisons based on breeding groups.

Table 88 (Continued)

Source of variations	Degrees of freedom		Mean squares			
			Kanawha 1968	Martinsburg 1968	Newell 1968	Grundy Center 1968
Among 3 x generations	9		2.43**	1.18**	1.35*	0.56
Linear		3	4.53**	2.63**	2.90**	0.04
Quadratic		3	0.55	0.23	0.52	0.53
Cubic		3	2.21**	0.67	0.67	1.12
Among 4 x generations	15		0.70	0.51*	0.57	0.89*
Linear		5	1.57**	0.96**	0.44	1.76**
Quadratic		5	0.23	0.21	0.96	0.35
Cubic		5	0.29	0.34	0.31	0.53
Error (b)	120		0.45	0.26	0.59	0.43
Total	239					
c.v. %			4.14	4.25	5.09	4.57
			Ames 1968	Ankeny 1968	Newell 1967	Ames 1967
Replications	2		0.39	3.88**	5.52*	3.84*
Families[a]	19		4.36**	6.69**	10.54**	5.45**
(1&2) vs (3&4)		1	0.06	0.92	1.35	0.63
1 vs 2		1	0.63	0.32	3.65	9.80**
3 vs 4		1	11.44**	3.15**	13.35**	13.44**
Among 1		3	2.37**	3.04**	11.82**	2.15
Among 2		5	5.96**	12.16**	10.96**	7.11**
Among 3		3	10.48**	13.06**	19.91**	7.71**
Among 4		5	0.27	2.72**	6.78**	2.89*
Error (a)	38		0.52	0.33	1.60	0.86
Generations	3		0.19	0.68	1.15	0.20
Linear		1	0.50	0.00	3.13	0.51
Quadratic		1	0.07	1.98*	0.16	0.02
Cubic		1	0.00	0.06	0.15	0.09
Families x generations	57		0.63	0.97**	2.19**	1.06**
{(1&2)vs(3&4)}x gen	3		0.36	0.13	0.74	0.22
Linear		1	0.07	0.18	0.48	0.03
Quadratic		1	0.70	0.04	1.68	0.33
Cubic		1	0.30	0.15	0.07	0.30
(1 vs 2) x generations	3		0.96	0.15	2.93*	0.54
Linear		1	0.90	0.13	3.61*	0.23
Quadratic		1	0.48	0.08	0.16	0.14
Cubic		1	1.49	0.25	5.02**	1.24

Table 88 (Continued)

Source of variations	Degrees of freedom	Mean squares Ames 1968	Ankeny 1968	Newell 1967	Ames 1967
(3 vs 4) x generations	3	0.44	0.53	3.87**	0.53
Linear	1	0.62	0.36	10.57**	1.66*
Quadratic	1	0.07	0.14	0.02	0.50
Cubic	1	0.63	1.10	1.03	0.43
Among 1 x generations	9	0.64	0.85	2.04*	0.82*
Linear	3	0.32	1.24*	3.20*	1.11*
Quadratic	3	0.32	0.17	0.72	0.36
Cubic	3	1.27	1.16*	2.20*	1.04*
Among 2 x generations	15	1.21**	1.49**	2.66**	1.40**
Linear	5	1.48*	3.17**	5.91**	2.18**
Quadratic	5	0.70	1.02*	1.22	1.44**
Cubic	5	1.44*	0.28	0.86	0.58
Among 3 x generations	9	0.33	1.40**	2.19*	1.91**
Linear	3	0.11	1.47*	2.44*	2.61**
Quadratic	3	0.49	0.88	2.48*	1.61**
Cubic	3	0.39	1.85**	1.64	1.51**
Among 4 x generations	15	0.25	0.70	1.62*	0.66
Linear	5	0.15	0.76	2.26*	0.39
Quadratic	5	0.44	0.42	1.75	1.21**
Cubic	5	0.15	0.91	0.86	0.37
Error (b)	120	0.53	0.42	0.83	0.38
Total	239				
c.v. %		4.68	5.33	5.55	4.51

Table 89. Mean yields for testcrosses of four generations in 20 selected families, averaged for eight environments

	Entry no.	Ch	F_2[a]	F_3[a]	F_4[a]	R_ℓ	R_q
Group 1[b]	03	69.8	73.4	78.2	76.7	1.275	-1.275
	04	74.1	75.9	75.5	74.9	0.100	-0.600
	05	71.2	74.5	73.3	76.4	0.720	-0.050
	10	74.8	69.9	73.6	70.4	-0.475	0.425
	$\bar{x}$	72.5	73.4	75.2	74.6	0.405	-0.375
Group 2[b]	01	74.4	73.7	76.2	76.2	0.395	0.175
	02	71.9	73.2	74.4	76.8	0.795	0.275
	06	73.0	65.7	70.0	70.3	-0.190	1.900
	07	72.2	61.1	61.0	67.9	-0.650	4.500
	08	73.1	67.9	67.4	64.2	-1.360	0.500
	09	72.1	64.2	66.6	64.4	-1.035	1.425
	$\bar{x}$	72.8	67.6	69.3	70.0	-0.343	1.463
Group 3[b]	14	70.7	72.9	74.7	75.2	0.765	-0.429
	15	71.3	76.2	75.9	77.7	0.945	-0.775
	19	71.3	74.7	69.4	68.6	-0.670	-1.050
	20	72.4	70.2	70.9	71.8	-0.0555	0.775
	$\bar{x}$	71.4	73.5	72.7	73.3	0.246	-0.370
Group 4[b]	11	70.2	72.3	71.8	73.0	0.395	-0.225
	12	70.0	70.2	71.8	75.3	0.875	0.825
	13	73.1	72.9	76.5	75.6	0.555	-0.175
	16	70.6	72.3	73.3	72.9	0.395	-0.525
	17	67.5	71.3	72.1	69.3	0.310	-1.650
	18	70.2	69.5	72.6	74.6	0.815	0.675
	$\bar{x}$	70.3	71.4	73.0	73.5	0.559	-0.179
Group 1 and 2 mean		72.7	70.5	72.3	72.3	0.031	0.544
Group 3 and 4 mean		70.9	72.5	72.9	73.4	0.403	-0.275

[a]Generation.

[b]Grouping based on breeding methods.

Table 90. Mean grain moisture at harvest for testcrosses of four generations in 20 selected families, averaged for eight environments

	Entry no.	Ch	F_2[a]	F_3[a]	F_4[a]	R_ℓ	R_q
Group 1[b]	03	24.7	24.7	24.1	24.0	-0.135	-0.025
	04	24.3	25.3	25.4	26.5	0.325	0.025
	05	23.9	24.7	24.0	23.8	-0.050	-0.250
	10	21.4	22.2	23.3	22.4	-0.200	0.250
	$\bar{x}$	23.8	24.2	24.2	24.2	-0.015	0.000
Group 2[b]	01	24.0	25.1	23.4	23.1	-0.220	-0.350
	02	24.4	25.5	27.0	26.8	0.435	-0.325
	06	24.7	22.9	22.4	22.1	-0.415	0.375
	07	24.6	23.4	24.1	23.7	-0.100	0.200
	08	23.9	24.7	24.5	23.6	-0.055	-0.425
	09	25.0	27.1	27.2	27.2	0.335	-0.525
	$\bar{x}$	24.4	24.8	24.8	24.4	-0.003	-0.175
Group 3[b]	14	24.1	24.0	23.9	23.7	-0.065	-0.025
	15	25.3	27.8	27.8	28.9	0.540	-0.350
	19	24.6	25.2	24.1	25.3	0.050	0.150
	20	24.9	23.8	25.0	25.0	0.075	0.275
	$\bar{x}$	24.7	25.2	25.2	25.7	0.150	0.013
Group 4[b]	11	24.8	24.5	23.1	23.7	-0.235	0.225
	12	24.4	23.4	22.9	22.9	-0.250	0.250
	13	24.1	24.1	24.8	24.7	0.125	-0.025
	16	24.4	25.2	25.6	24.6	0.050	-0.450
	17	24.9	23.5	24.1	23.9	-0.120	0.300
	18	24.3	24.4	24.3	23.5	-0.125	-0.225
	$\bar{x}$	24.5	24.2	24.1	23.9	-0.093	0.013
Group 1 and 2 mean		24.1	24.5	24.5	25.3	-0.009	-0.088
Group 3 and 4 mean		24.6	24.7	24.7	24.8	0.028	0.013

[a]Generation.

[b]Grouping based on breeding methods.